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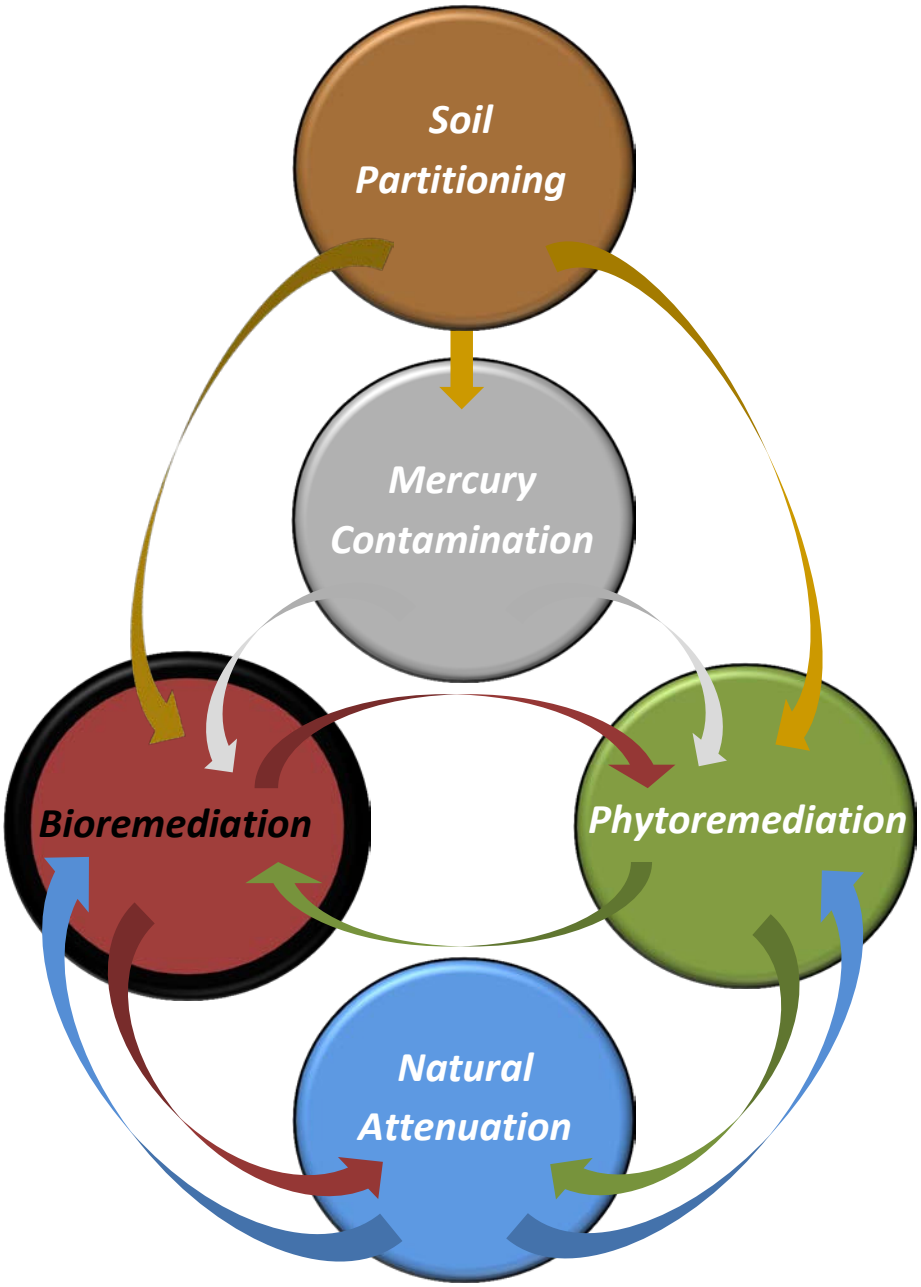
Evaluation of Bioremediation of Soil Contaminants

Soil Treatability Studies

Area IV Santa Susana Field Laboratory

Ventura County, California



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Study Plan
Soil Treatability Studies
Area IV Santa Susana Field Laboratory
Ventura County, California

Evaluation of Bioremediation of Soil Contaminants

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Soil Treatability Studies
Area IV Santa Susana Field Laboratory
Ventura County, California

Evaluation of Bioremediation of Soil Contaminants

Contract DE-EM0001128
CDM Smith Task Order DE-DT0003515

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Acronyms and Abbreviations

AOC	Administrative Order on Consent
Cal Poly	California Polytechnic State University, San Luis Obispo
CDM Smith	CDM Federal Programs Corporation
COI	contaminant of interest
dioxin	polychlorinated dibenzo-p-dioxins
DNA	deoxyribonucleic acid
DOE	United States Department of Energy
DTSC	California Environmental Protection Agency Department of Toxic Substances Control
g	gram
ITS	intergenic transcribed spacer
kg	kilogram
L	liter
M	molar
mg	milligram
ml	milliliter
oz	ounce
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PCR	polymerase chain reaction
PDA	potato dextrose agar
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
rpm	revolutions per minute
Sandia	Sandia National Laboratories
SOP	standard operating procedure
SSFL	Santa Susana Field Laboratory
STIG	Soil Treatability Investigation Group
TPH	total petroleum hydrocarbons
TRFLP	Terminal Restriction Fragment Length Polymorphism analysis
TSA	Trypticase Soy Agar
UC Riverside	University of California, Riverside

List of Standard Operating Procedures

Identified Data Gap Phase 3 Standard Operating Procedures (SOPs) (Appendix D)

SSFL SOP 1, Procedures for Locating and Clearing Phase 3 Samples
SSFL SOP 3, Subsurface Soil Sampling with Hand Auger
SSFL SOP 4, Direct Push Technology (DPT) Sampling
SSFL SOP 6, Field Measurement of Total Organic Vapors
SSFL SOP 7, Field Measurement of Residual Radiation
SSFL SOP 8, Field Data Collection Documents, Content and Control
SSFL SOP 9, Lithologic Logging
SSFL SOP 10, Sample Custody
SSFL SOP 11, Packaging and Shipping Environmental Samples
SSFL SOP 12, Field Equipment Decontamination
SSFL SOP 13, Guide to Handling Investigation Derived Waste
SSFL SOP 15, Photographic Documentation of Field Activities
SSFL SOP 16, Control of Measurement and Test Equipment
SSFL SOP 17, Laboratory Homogenization for Phase 3 Soil Samples

Identified Standard Operating Procedures from other Soil Treatability Studies (Appendix E)

SSFL SOP ST PHY 6, Field Homogenization of Soil Samples
SSFL SOP ST PHY 7, Laboratory Sampling Equipment Decontamination
SSFL SOP ST PHY 9, Bulk Soil Homogenization
SSFL SOP ST PHY 10, Cal Poly Laboratory Data Collection, Documents, Content, and Control
SSFL SOP ST PHY 11, Guide to Handling Experiment-Derived Waste

Bioremediation Treatability Study Standard Operating Procedures (Appendix F)

SSFL SOP ST BIO 1, Bioremediation Microcosm Preparation and Operation
SSFL SOP ST BIO 2, TRFLP Analysis
SSFL SOP ST BIO 3, Guide to Handling Bioremediation Treatability Experiment-Derived Waste

Section 1
Introduction

This document details the study plan to undertake and complete the bioremediation soil treatability study for Area IV of the Santa Susana Field Laboratory (SSFL). The study includes a literature review (Section 4.1) and two research phases. Phase 1 of the study (Section 4.2) will involve collecting samples from Area IV soils to identify contaminant degrading bacteria and fungi currently present in Area IV soils. Phase 2 of the study (Section 4.3) will use laboratory soil microcosms to:

- Determine the likely extents and rates of contaminant biodegradation occurring in Area IV soils.
- Investigate the potential of biostimulation (addition of nutrients) to increase these biodegradation rates and/or facilitate end-product contaminant degradation mechanisms.
- Investigate the potential of bioaugmentation (addition of additional microorganisms) to increase these biodegradation rates and/or facilitate end-product contaminant degradation mechanisms.

The bioremediation soil treatability study is one of a series of five soil treatability studies being conducted by the Department of Energy (DOE) in compliance with the Administrative Order on Consent (AOC) that DOE signed with the California Environmental Protection Agency Department of Toxic Substances Control (DTSC) in 2010. The AOC specifies the cleanup standards for Area IV. Included within Section 2.6 of the AOC is a requirement for DOE to conduct soil treatability studies to develop data for assessing treatment in place that could achieve clean up goals. This study plan partially addresses the AOC requirement to conduct soil treatability studies. DTSC has the regulatory authority for approving and accepting the results of all Area IV treatability studies. The overall objectives and relationships of these five soil treatability studies are described in the *Master Work Plan, Soil Treatability Studies, Area IV of SSFL* (CDM Smith 2013).

This study plan was jointly developed by California Polytechnic State University (Cal Poly) and CDM Federal Programs Corporation (CDM Smith) to identify and describe the scope and steps required to conduct the Evaluation of Bioremediation of Soil Contaminants treatability study. This study plan has been developed under CDM Smith contract No. DE-EM0001128, Task Order DE-DT0003515.

1.1 Purpose of Study

The purpose of the study is to assess the ability of bioremediation to reduce soil contaminant levels to concentrations at or below the AOC Soil Chemical Look-up Table values (Appendix C). The contaminants of interest (COI) for the study are a subset of the soil contaminants observed in Area IV, reflecting those contaminants determined to be most amenable to bioremediation. The COIs to be investigated for potential bioremediation in this study are:

- polyaromatic hydrocarbons (PAHs),
- total petroleum hydrocarbons (TPH),
- polychlorinated biphenols (PCBs), and

- polychlorinated dibenzo-p-dioxins (dioxins).

This treatability study, along with the other four soil treatability studies, will support the evaluation of methods for reducing the volume of contaminated soils that may need to be removed from Area IV by more traditional remediation methods, such as excavation and offsite transportation/disposal.

1.2 Overview of Study

DOE initiated the treatability study process in May 2011 when it contracted Sandia National Laboratories (Sandia). Sandia's role was to evaluate potential soil remediation methods and to make recommendations as to what treatment technologies may be applicable to Area IV. DOE concurrently engaged a community working group, the Soil Treatability Investigation Group (STIG), to participate during the course of Sandia's evaluation of treatability study options. STIG attended Sandia-led meetings and provided input on the selection of technologies that would be evaluated during the soil treatability studies.

Some of Sandia's recommendations to evaluate potential soil remediation methods were to determine (adapted from Sandia, 2012):

- What biota/microbiota are currently present in SSFL soils which may be capable of biodegrading the COIs?
- What is the baseline rate of biodegradation, if any, for the various COIs in the affected soils?
- What nutrients/additives can be used to enhance native biota/microbiota degradation rates (i.e., biostimulation)?
- What non-native biota/microbiota could be used to enhance degradation of existing COIs without interfering with native biota?

This bioremediation soil treatability study has been developed to answer these questions in two phases. Phase 1 of this treatability study will involve collecting soil samples from Area IV and using both culturing techniques and molecular methods to identify COI degrading bacteria and fungi in the soil and the microbial community as a whole. Phase 2 of this treatability study will use laboratory microcosms to determine COI degradation extents and rates, and also to investigate means of increasing these degradation rates and/or facilitating end-product degradation mechanisms through biostimulation and/or bioaugmentation.

The results of this treatability study will provide site specific bioremediation extents and rates for Area IV COIs, will inform potential follow-up treatability studies, and will help guide future Area IV remediation decisions.

1.3 Study Plan Structure

The remainder of this study plan is organized as follows:

- Roles and Responsibilities of Study Team
- Study Basis
- Study Approach

  - Literature Review
  - Treatability Study Phase 1: Assessment of Area IV Microbial Communities and Biodegradation Products
  - Treatability Study Phase 2: Laboratory Microcosm Experiments
  - Health and Safety Requirements
  - Quality Assurance/Quality Control Requirements
- Study Report Description
- Study Schedule
- Study References

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Section 2

Roles and Responsibilities of Study Team

The bioremediation study team consists of seven entities. These entities, and their roles and responsibilities, are briefly described below.

DOE is a responsible party for Area IV of SSFL and is providing funding for this study.

CDM Smith will provide overall project management and contracting, is jointly responsible for preparing this study plan and the subsequent bioremediation soil treatability study report with Cal Poly, performing field sample collection, conducting this study with Cal Poly and the contract laboratories, and working with DTSC to gain regulatory acceptance of this study plan and the bioremediation soil treatability study report.

Cal Poly is jointly responsible for preparing this study plan and the subsequent bioremediation soil treatability study report with CDM Smith, conducting this study with CDM Smith and the contract laboratories, performing the soil microbial assays and microcosm experiments, and presenting the bioremediation soil treatability study report to STIG.

DTSC is the regulatory agency over Area IV of SSFL and retains ultimate approval authority of this study plan and the bioremediation soil treatability study report.

University of California, Riverside (UC Riverside) will be concurrently conducting a soil partitioning study. As part of their study, UC Riverside will be evaluating how strongly bound the COIs are to the soil particles, which is an indication of the bioavailability of the COIs to plants and microbes.

Contract laboratories will perform chemical analyses of the soil samples and soil amendments. The contract laboratories will be EMAX and Lancaster.

STIG will continue to participate during the progress of this study and will be updated on progress and results.

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Section 3

Study Basis

The biodegradation of petroleum hydrocarbons, including PAHs, is well established (e.g. Venosa 1996) and is a promising technology for decreasing their concentrations in soil. Both dioxins and PCBs are also known to biodegrade. However, these degradation processes often occur at a much slower rate than what has been observed for petroleum hydrocarbons (Halden and Dwyer 1997; Field and Sierra-Alvarez 2008; Abramowitz 1995; Sowers and May 2012). These slower degradation rates are due to the complex sequence of anaerobic and aerobic processes required for dioxin and PCB biodegradation.

The site-specific research in this study will determine the feasibility of bioremediation for the degradation of COIs in Area IV soils. Field studies are needed to determine if microorganisms capable of biodegrading the COIs are present at the site, specifically bacteria and fungi. Laboratory microcosms are needed to quantify the potential extents and rates of biodegradation under natural field conditions and also to determine if biodegradation can be stimulated by the addition of nutrients, surfactants, bulking agents and/or bioaugmentation with known COI degrading bacteria and fungi (degraders).

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Section 4
Study Approach

The overall approach to the bioremediation soil treatability study will include a literature review (Section 4.1) and two major study phases. Phase 1 of this study (Section 4.2) will identify COI degrading bacteria and fungi present in Area IV soils by collecting soils from the site and subjecting these samples to culturing and microbial assays. Phase 2 of this study (Section 4.3) will use laboratory soil microcosms to determine site-specific rates of COI biodegradation occurring in Area IV. Phase 2 will also determine if biostimulation and/or bioaugmentation can increase COI degradation rates and/or facilitate end-product degradation mechanisms. The literature review and the two major study phases are detailed below.

4.1 Literature Review

The bioremediation literature review will be conducted concurrently with the natural attenuation literature review because biodegradation is one of the natural attenuation processes. The natural attenuation literature review will determine the biodegradability of the COIs, identify bacteria and fungi known to biodegrade each COI, and tabulate published rates of COI biodegradation from both field and laboratory studies. This information will be included in both the natural attenuation and bioremediation soil treatability study reports. The bioremediation literature review will focus on the applicability of biostimulation processes (such as aeration, nutrient supplementation, and surfactant addition) and bioaugmentation methods to Area IV soils and COIs.

The bioremediation literature review will also identify what intermediate or end-product degradation compounds may result from COI biodegradation. For example, PCBs and dioxins can be reductively dechlorinated by microbial populations. The reductive dechlorination process forms congeners of lower chlorine content than the parent compound. Therefore, an increase in the quantity of lower chlorine-content congeners during the laboratory microcosm experiments would suggest that the PCBs or dioxins are being broken down by the microbial communities.

The literature review will be conducted according to the following methodology:

1. The databases and journals used to research bioremediation of the COIs will include those listed below (accessed primarily through the Cal Poly Library System):
    a. Science Citation Index (Web of Knowledge/Web of Science)
    b. Science Direct
    c. BIOSIS
    d. Google Scholar
2. Journals with specific relevance will be searched, including, but not limited to:
    a. Environmental Science and Technology
    b. Bioremediation

c. Applied Environmental Microbiology

d. Environmental Toxicology and Chemistry

e. Chemosphere

f. Journal of Soils and Sediments

3. Papers and abstracts from conference proceedings will also be used, such as:

   a. Battelle Conference on Chlorinated and Recalcitrant Compounds

   b. Symposium on Bioremediation and Sustainable Environmental Technologies

   c. American Chemical Society Division of Environmental Chemistry

4. Review articles (articles providing critical evaluation of previously published studies) will be used to help identify the most important studies and provide a broad perspective and identify important prior publications.

5. All information cited will be obtained from the original papers in which information was published (not as cited by subsequent publications).

6. All publications will be indexed into a database using Endnote or Mendeley.

7. Colleagues and professionals with experience in the field of bioremediation of the COIs will be contacted via email and telephone for guidance in:

   a. Identifying other current researchers in this area.

   b. Identifying field sites with similar COIs.

8. An attempt will be made to identify field sites analogous to Area IV for which past research could be applied to estimating bioremediation potential at this site. Such "analogous" sites will ideally meet the following criteria:

   a. Soils are of similar type to those found in Area IV (sandy loam).

   b. Concentrations of COIs are within the range of levels measured at Area IV.

   c. Climate is similar to Area IV (temperatures, rainfall).

4.2 Treatability Study Phase 1: Assessment of Area IV Microbial Communities and Biodegradation Products

This section details the tasks associated with Phase 1 of this study. Phase 1 will include the following tasks:

- sample location selection,
- soil sample collection,
- culturing of COI degrading bacteria from soil samples,

- culturing of COI degrading fungi from soil samples,
- 16S DNA sequencing of both bacteria and fungi,
- Terminal Restriction Fragment Length Polymorphism (TRFLP) analysis of the microbial communities (both bacteria and fungi),
- metagenomics characterization of the microbial communities (both bacteria and fungi), and
- chemical assays to identify possible COI end products and/or intermediates formed during COI biodegradation as evidence for in situ Area IV biodegradation.

The purpose of these assays is to determine if bacteria and/or fungi known to degrade each of the COIs are present in Area IV soils. The assays will include microbial culturing techniques and two more recently developed molecular methods. These assays are introduced below and further described in Section 4.2.3 (*Culturing of COI Degrading Bacteria*), 4.2.4 (*Culturing of COI Degrading Fungi*), 4.2.5 (*TRFLP Analysis*), and 4.2.6 (*Metagenomics Analysis*).

- Classic culturing techniques and DNA sequencing: Specific COI degrading bacteria and fungi will be cultured in the laboratory from Area IV soil samples. 16S DNA sequencing will subsequently be used to determine the identity of these cultured bacteria and fungi. A literature review will determine if these microorganisms have demonstrated biodegradation abilities for the specific COIs in other studies.
- TRFLP analysis: DNA extracted from soil samples will be analyzed to determine the genetic diversity of the soil microbial community. This analysis will attempt to identify specific COI degrading bacteria and fungi by comparing TRFLP analysis results with those in published scientific literature.
- Metagenomics: This assay will determine the specific composition of the microbial community and identify COI degrading bacteria and fungi in soil samples. Metagenomics is a recently developed technique that is expected to give more detail on bacteria and fungi species in the soil samples than either TRFLP analyses or classic culturing techniques. However, the TRFLP analyses and classic culturing techniques will also be conducted to provide verifications of the metagenomic assays. These techniques and methods are summarized in the following paragraphs, and detailed descriptions of the methods are provided in subsequent sections of this study plan.

A process to isolate COI degrading bacteria and fungi from Area IV soils will be attempted by using selective microbial growth media. These media will contain the class of COI (e.g., dioxin, PAH, etc.) that the degrader is thought to be degrading. This process will ideally provide pure cultures of COI degrading bacteria and fungi native to Area IV soils. 16S sequencing analysis of these degraders will then be used to identify the cultured bacteria and/or fungi species. Once identified, a literature review will determine if these species have been shown to be capable of COI biodegradation in other studies and, if so, at what rates. 16S sequencing is a standard molecular tool and can identify most bacteria and fungi down to the genus level.

TRFLP is a molecular method that provides a "genetic snapshot" of microbial communities (e.g. Kaplan and Kitts, 2004). DNA is extracted from the soil sample and digested by restriction enzymes, creating a wide range of DNA fragment sizes. These fragments are then analyzed on a fragment analyzer. The

fragment analyzer provides a frequency graph of each DNA fragment, creating the "genetic snapshot" of the soil sample. TRFLP analysis will be performed on soil samples from multiple Area IV locations with varying COI concentrations. These analyses will help to determine the microbial diversity in the soils and possibly determine if known COI degrading bacteria and fungi are present in the soil samples.

Metagenomics is a newer DNA analysis technique that uses quantified DNA to provide details about the genus and species-level identification of bacteria and fungi present in a soil sample. This information will quantify each bacteria and fungi species present in a soil sample. This information will be used to determine if biodegradation of the COIs is likely to be occurring at Area IV.

4.2.1 Treatability Study Phase 1 Soil Sample Location Selection

Bioremediation Treatability Study Phase 1 soil samples will be collected from locations with varying COI concentrations within Area IV. Soils will be analyzed (as discussed in the remainder of Section 4.2) to determine if microbial populations correlate with COI concentrations. Correlating bacteria and/or fungi species with COI concentrations could be useful for identifying COI degraders based on COI distribution. Published literature will be researched for the species identified in the soil by the metagenomics assay results to determine if these species have been previously identified to biodegrade the COIs.

Soil sample locations will have ranges of TPH, PAH, dioxin, and PCB concentrations. These concentration ranges will extend from "non-detects" to maximum target concentrations (presented below). Ten soil samples of varying COI concentrations will be collected for each COI class. PAH and TPH concentration trends are similar at the proposed sample locations, suggesting that these COIs are collocated. Therefore, Phase 1 of this study treats TPH and PAH as a single COI class and combines them into a single set of 10 soil sample locations for analyses and experiments. Ten soil samples will be collected for dioxin analyses and experiments. Ten soil samples will be collected for PCB analyses and experiments. A total of 30 soil samples will be collected for Phase 1 analyses and experiments.

The proposed soil sample locations will have a maximum target COI concentration of:

- 500 parts per million (ppm) for TPH or 8 ppm for PAH,
- 0.02 ppm for dioxins, and
- 1 ppm for PCBs.

Bioremediation Treatability Study Phase 1 sample locations are plotted on Figure 4-1. Sample location selection for the Bioremediation Treatability Study Phase 2 soil samples is described in Section 4.3.1 of this study plan.

4.2.2 Treatability Study Phase 1 Soil Sample Collection and Chemical Analysis

Sample locations will be screened for total organic vapors (per SSFL SOP 6, *Field Measurement of Total Organic Vapors*) and residual radiation (per SSFL SOP 7, *Field Measurement of Residual Radiation*) prior to sample collection. These and other applicable soil clearing, sampling, and handling procedure SOPs are contained in the *Master Field Sampling Plan for Chemical Data Gap Investigation, Phase 3 Soil Chemical Sampling at Area IV, Santa Susana Field Laboratory; Ventura County, California; April 2012* ("*Data Gap Phase 3 Work Plan*"; CDM Smith 2012b) and in Appendix D of this document. Candidate sample locations will also be chemically analyzed to ensure that bioremediation treatability study

samples are not taken from soils with COI concentrations exceeding federal or California regulatory levels for hazardous wastes, and that the soils meet the COI concentration criteria listed in this study plan (Section 4.2.1). Soil sampling will conform to procedures described in the *Data Gap Phase 3 Work Plan*. Bioremediation Treatability Study Phase 1 soil samples will be collected from a depth interval of 1 to 4 feet (ft) below the ground surface at each sample location, per either SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger* or SSFL SOP 4, *Direct Push Technology (DPT) Sampling*.

Each 1 to 4 ft depth interval soil sample will be homogenized per SSFL SOP ST PHY 6, *Field Homogenization of Soil Samples* (Appendix E of this document). The homogenized sample will then be split for chemical analyses by the contract laboratories (EMAX and Lancaster) and microbial analyses by Cal Poly. The analyses to be performed by the contract laboratories are presented in Table 4-1. The required soil mass and target soil volumes for chemical analyses are presented in Table 4-2. Cal Poly requires a single 8-ounce glass jar of soil, with a Teflon lined lid, from each sample location for microbial analyses. Samples will be delivered to the laboratories per SSFL SOP 11, *Packaging and Shipping of Environmental Samples* (Data Gap Phase 3 Work Plan).

4.2.3 Culturing of COI Degrading Bacteria

This study will attempt to grow pure cultures of COI degrading bacteria through enrichments on defined media. Bushnell-Haas base medium (Section 4.2.3.1), which is a nutrient medium containing no carbon, will be used as a base for preparing these media. Each COI (or surrogate) will be added individually to plates containing the Bushnell-Haas base medium. Since the growth medium will lack a carbon source except for carbon associated with the added COI, only degraders of that COI will be able to grow on that plated medium. The microbial colonies that grow on this plated medium will be transferred to a fresh set of plates to ensure that the microorganisms were not introduced to the first plate accidentally. This technique has been used to isolate and identify TPH degrading bacteria from a commercial bioaugmentation product (Lehrer 2012) and will be applied with slight variations to TPH degraders, PAH degraders, PCB degraders, and dioxin degraders, as described below. The metagenomics assay (Section 4.2.6) will provide detailed species-specific identification of bacteria present in Area IV soil samples. This culturing of COI degrading bacteria will be used to verify the metagenomics results.

All non-disposable equipment used in Cal Poly's laboratory experiments will be decontaminated per *SSFL SOP ST PHY 7, Laboratory Sampling Equipment Decontamination.* All Cal Poly experiment-derived waste will be handled per *SSFL ST BIO 3, Guide to Handling Bioremediation Treatability Experiment-Derived Waste.* Cal Poly researchers will document all laboratory procedures and observations per *SSFL SOP ST PHY 10, Cal Poly Laboratory Data Collection, Documents, Content, and Control.*

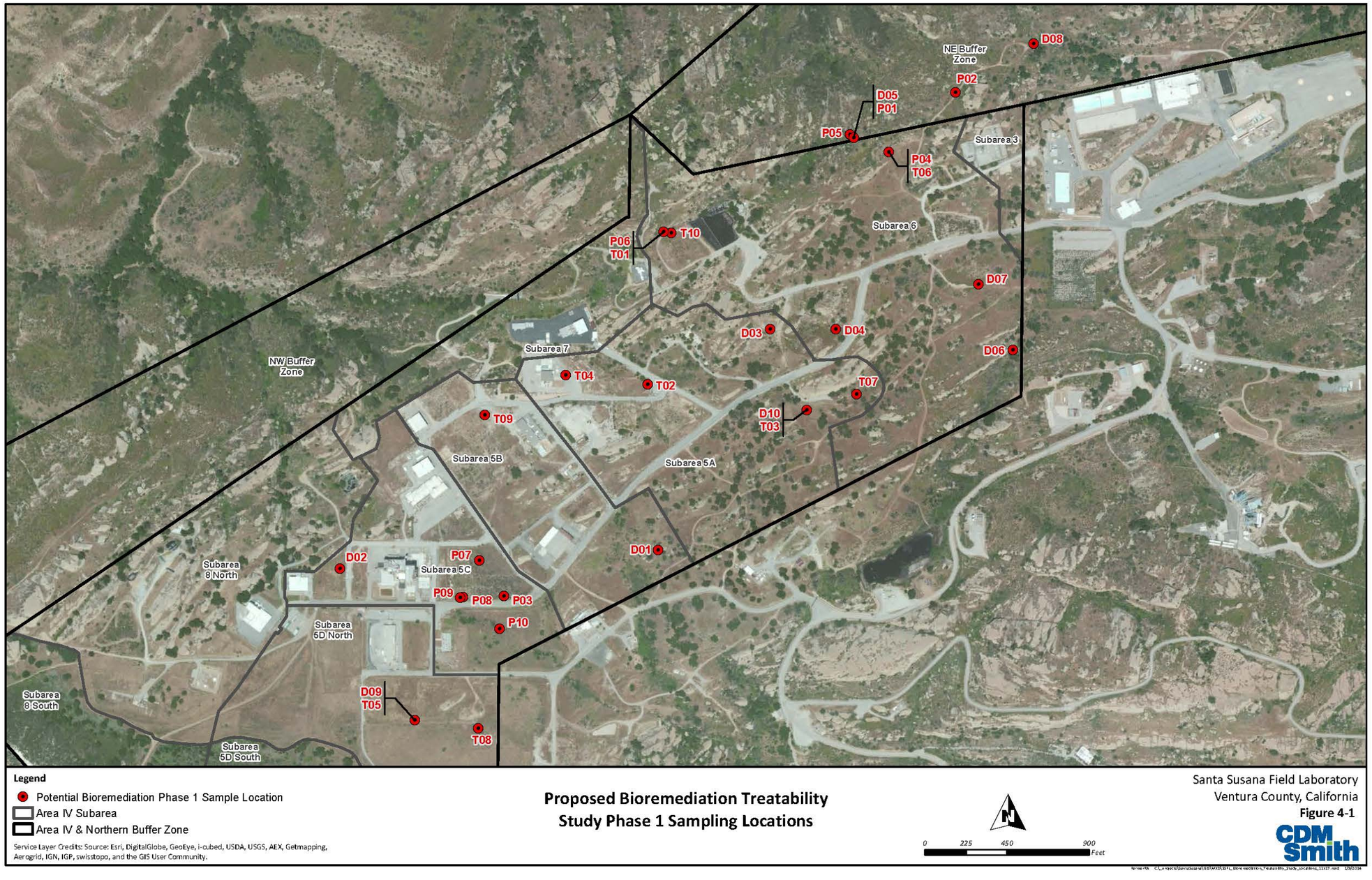

Figure 4-1: Proposed Bioremediation Treatability Study Phase 1 Sampling Locations

Table 4-1 Method number/title for contract laboratory chemical analyses

Analyte	Analytical Methods for Soil	Analytical Methods for Liquid
PCBs	EPA Method 8082A Gas Chromatograph/Electron Capture Detector	EPA Method 8082A Gas Chromatograph/Electron Capture Detector
Dioxins	EPA Method 1613B Gas Chromatograph/ High Resolution Mass Spectroscopy	EPA Method 1613B Gas Chromatograph/ High Resolution Mass Spectroscopy
PAHs	EPA Method 8270C/D SIM Gas Chromatograph/ High Resolution Mass Spectroscopy	EPA Method 8270C/D SIM Gas Chromatograph/ High Resolution Mass Spectroscopy
TPH	EPA Method 8015B/C/D Gas Chromatograph/Flame Ionization Detector	EPA Method 8015B/C/D Gas Chromatograph/Flame Ionization Detector
Metals	EPA Method 6010C/6020A/7471B Inductively Coupled Plasma -Atomic Emission Spectrometry, Inductively Coupled Plasma -Mass Spectrometry Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)	EPA Method 6010C/6020A/7470B Inductively Coupled Plasma -Atomic Emission Spectrometry, Inductively Coupled Plasma -Mass Spectrometry, Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)
Mercury	Cold vapor atomic absorption spectroscopy EPA Method 7471B	Cold vapor atomic absorption spectroscopy EPA Method 7470B
Percent Moisture	ASTM D2216	Not applicable
Nitrogen	ASTM D5373	ASTM D5373
Organic Carbon	SM 5310B	SM 5310B

Slight variations in the aforementioned technique will be used for the various COIs because of the different expected biodegradation mechanisms for each COI. For example, petroleum hydrocarbons may be biodegraded directly by microorganisms using these compounds as their source of carbon. On the other hand, PCB and dioxin biodegradation may occur through co-metabolic processes involving other carbon sources and/or sequential anaerobic/aerobic mechanisms. For microorganisms degrading the COIs via co-metabolism, more complex strategies must be employed. These strategies are described in the following sections.

Once microbial colonies are isolated on their specific growth media, the colonies will be selected and grown on Trypticase Soy Agar (TSA) plates. TSA is a non-specific growth medium, and TSA plates will be used to grow cells for characterization and 16S sequencing. 16S sequencing will be used to identify each strain of bacteria. DNA will be extracted from isolates, followed by amplification of appropriate gene targets using the polymerase chain reaction (PCR). Once COI degraders are identified, a literature search will be conducted to determine if biodegradation of the COIs has been reported for these degraders.

Table 4-2 Required sample mass and target sample volumes for analyses

Analyte	Subcontract Laboratory Required Soil Mass[a,b] (gram)	Subcontract Laboratory Target Soil Volume (ounce)	Subcontract Laboratory Required Liquid Volume (milliliter)
PCB	30	8[b]	1000
Dioxins[c]	10	4	1000
PAH	30	8[b]	1000
TPH	15	8[b]	1000
Metals	5	8[b]	500
Mercury	3	8[b]	250
Methyl Mercury	3	8[b]	250
Percent Moisture	10	8[b]	Not Applicable
Nitrogen	75	8[b]	250
Organic Carbon	50	8[b]	500
Total	**231**	12[b]	**5750**

a: Cal Poly requires a single 8-ounce glass jar of soil, with a Teflon lined lid, from each sample location for microbial analyses (Sections 4.2.3.2, 4.2.3.3, 4.2.3.4, 4.2.3.5, and 4.2.4).
b: These masses are based on estimated soil moisture of 12%
c: A single 8-ounce sample jar will be collected for PCBs, PAHs, TPH, metals, mercury, moisture, and nitrogen analyses by EMAX. A single 4-ounce sample jar will be collected for dioxin analyses by Lancaster.

4.2.3.1 Bushnell-Haas Base Medium

Bushnell-Haas base medium is a commercially available nutrient medium that provides microbes with major nutrients but no carbon or energy source. A carbon source can be added in the form of an organic molecule to make the media selective for the COI degraders. A selective medium means that if a single COI is added as a carbon source to the Bushnell-Haas base medium, microbial colonies formed on the plate will be colonies that can degrade that COI. For example, if Bushnell Hass medium with phenanthrene added is plated, any microorganisms grown on that plate are likely to be phenanthrene degraders. The composition of Bushnell-Haas base medium is shown in Table 4-3.

Table 4-3 Composition of Bushnell-Haas base medium

Component	Concentration (gram/liter)
Magnesium Sulfate	0.2
Calcium Chloride	0.02
Monopotassium Phosphate	1.0
Dipotassium Phosphate	1.0
Ammonium Nitrate	1.0
Ferric Chloride	0.05
Final pH 7.0 +/- 0.2 at 25°C Ref: Sigma Aldrich 2013	

4.2.3.2 Culturing of TPH Degraders

TPH degrading bacteria will be cultured from Area IV soil samples using the methodology described in Section 4.2.3. This culturing will include plating onto agar plates with Bushnell-Haas base medium combined with 100 ppm 30-W motor oil. TPH mixtures at Area IV are likely to be highly weathered. These weathered TPH mixtures will contain higher molecular weight hydrocarbons because the lighter hydrocarbons have volatilized and/or biodegraded. Motor oil is selected as a model COI surrogate because it contains a mixture of high molecular weight hydrocarbons.

4.2.3.3 Culturing of PAH Degraders

PAH degrading bacteria will be cultured from Area IV soil samples using methodology similar to that used for TPH degraders (Section 4.2.3.2). PAH degrading bacteria culturing will include plating onto agar plates with Bushnell-Haas base medium combined with 50 ppm naphthalene. Based on the results of the literature review, naphthalene was chosen as the sole PAH carbon source for culturing PAH degraders.

Research literature states that using a mixture of various PAHs in carbon-free media for culturing PAH degraders will produce similar results as using only naphthalene as the carbon source. If a bacterium is capable of degrading a 5-ring PAH, it can also degrade PAHs with 2, 3, and 4 rings. Research studies using mixtures of PAHs as the carbon source for culturing have shown that these bacteria capable of degrading larger PAH molecules will degrade the smaller PAHs (e.g., PAHs with fewer aromatic rings, like naphthalene), if given a choice of PAH molecules with various numbers of aromatic rings (Gibson et al, 1968; Cerniglia, 1992, Haritash & Kaushik, 2009). This means that if a mixture of PAHs is used for culturing of PAH degraders, the smaller PAH molecules (like naphthalene) will be used by the bacteria as a carbon source.

Microbial growth on Bushnell-Haas base medium combined with 50 ppm naphthalene does not demonstrate the ability of the isolated bacteria to degrade larger PAH molecules. Rather, this culturing approach is being used to isolate bacteria in the soil sample. Once isolated, these bacteria will be sequenced to determine if the cultured species are reported in the scientific literature to be capable of degrading the larger PAH molecules.

4.2.3.4 Culturing of PCB Degraders

Culturing of PCB degrading bacteria is more complex than culturing of PAH or TPH degrading bacteria. PCBs are typically biodegraded by multiple microorganisms, such as a consortium of anaerobic and aerobic bacteria, and the anaerobic dechlorination mechanism is typically co-metabolic. Often the first step of PCB biodegradation is anaerobic reductive dechlorination of highly chlorinated congeners to congeners of lower chlorine content. These lower chlorine congeners are then susceptible to aerobic biodegradation. The presence of these lower chlorine content congeners in the soils would suggest that the necessary anaerobic PCB degraders are present. The soil samples from the Phase 2 microcosms will be analyzed to compare the chlorine content of PCB congeners at the beginning of the Phase 2 study to the chlorine content of congeners after 4 and 9 months of microcosm operation. Lower chlorine content in the 4 and 9 month samples would suggest a line of evidence for the presence of PCB degraders in Area IV soils.

Culturing of aerobic PCB degraders will focus on isolating aerobic bacteria that can grow on lower chlorine content congeners that result from anaerobic dechlorination of higher chlorine content parent chemicals. Bushnell-Haas base medium will be prepared with a range of lower chlorine content PCB congener concentrations between 0.01 and 100 ppm. A control microorganism that is a known PCB degrader (e.g. *Pseudomonas sp*. 2fb-1) will be plated on the media to determine PCB concentrations that allow microbial growth but do not have toxic effects. The optimum PCB concentration will then be used to culture PCB degraders from Area IV soil samples. Aerobic PCB degrading bacteria will be cultured from Area IV soil samples using the methodology described in Section 4.2.3.

The PCB congener used for this culturing will be PCB 001, which is a monochlorinated PCB. This PCB is easier for microbial communities to degrade than a more chlorinated PCB. This culturing approach will be used to isolate bacteria in the soil sample. Once isolated, these bacteria will be sequenced to determine if the cultured species are reported in the scientific literature to be capable of degrading more chlorinated PCB molecules.

4.2.3.5 Culturing of Dioxin Degraders

Similar to PCB degrading bacteria, culturing of dioxin degrading bacteria is more complex than culturing of PAH or TPH degrading bacteria. Dioxins are typically biodegraded by multiple microorganisms, such as consortia of anaerobic and aerobic bacteria, and the anaerobic dechlorination mechanism is typically co-metabolic.

Bushnell-Haas base medium will be prepared with a range of dibenzofuran concentrations between 0.01 and 100 parts per billion (ppb). Dibenzofuran is being used as a model compound for the purposes of culturing potential degraders of dioxins. Control microorganisms that are known dioxin degraders (e.g., *Sphingomonas wittichii* RW1) will be used to determine dioxin concentrations that can allow growth of dioxin degraders without being toxic to the microorganisms. The optimum concentration will then be used to culture dioxins degraders from soil samples. Dioxin degrading bacteria will be cultured from Area IV soil samples using the methodology described in Section 4.2.3.

Since dioxins may be biodegraded by co-metabolism, this study will also attempt to grow dioxin degraders on an anaerobic degradation product of dioxins. Dibenzofuran is a likely product of anaerobic dioxin dechlorination, and thus Bushnell-Haas base medium with 1,000 ppb dibenzofuran will be used in the medium for this experiment (Monna et al. 1993). Dibenzofuran is easier for microbial communities to degrade than a more chlorinated dioxin. This culturing approach is being used to isolate bacteria in the soil sample. Once isolated, these bacteria will be sequenced to determine if the cultured species are reported in the scientific literature to be capable of degrading more chlorinated dioxins.

4.2.4 Culturing of COI Degrading Fungi

Fungi will be cultured using a fungi-specific growth medium. The fungi-specific growth medium will be Czapek–Dox + 0.5 % yeast extract agar, acidified with phosphoric acid to pH 4.0. A soil plate will be prepared by transferring a small amount of the Area IV soil into a sterilized Petri dish. Ten milliliters (ml) of cooled Czapek–Dox medium will be added and the soil will be dispersed throughout the agar plate. The appropriate amount of soil needed for each plate will be determined after the number of microorganisms present in a given mass of the soil is determined. Typically, 0.005 to 0.015 grams (g) of soil is added.

The plates producing isolated colonies will be used for further isolation of the fungal culture. Individual colonies isolated from these plates will be used to inoculate more plates, creating cell lines for characterization and sequencing the rRNA gene intergenic transcribed spacer region (ITS) to identify the species. While this growth medium can also support growth of some bacterial species, fungal colonies can be easily distinguished from bacterial colonies by their morphology.

Fungi capable of degrading lignin have also been shown to biodegrade chlorinated compounds (Pointing 2001). As a result, fungi will also be characterized using a chemical assay testing for lignin peroxidase. Isolated fungi cultures will be used to inoculate potato dextrose agar (PDA) and incubated in covered containers. Ten-ml aliquots of the culture will then be centrifuged at 5,000 revolutions per minute (rpm) for 15 minutes. Supernatant will then be inoculated into a 10-ml reaction mixture containing 1% alkaline lignin and 0.1 molar (M) phosphate buffer at pH 7. The reaction mixture will be incubated again and then tested for simple sugars using the 3,5-Dinitrosalicylic acid method to determine sugar concentration (Renugadevi et al. 2011). The presence of simple sugars will indicate the degradation of lignin, as sugars are the product of this reaction, and the possible presence of chlorinated compound degrading fungi.

4.2.5 TRFLP Analysis

TRFLP is a molecular method that provides a genetic snapshot of microbial communities (e.g., Kaplan and Kitts 2004). DNA is extracted from soil by washing the cells out of soil samples, filtering them, and lysing them. The DNA extracted from the soil is then amplified using PCR and digested by restriction enzymes, creating a wide range of DNA fragment sizes. These fragments are analyzed on a fragment analyzer, which provides a graph that shows the frequency of occurrence of each DNA fragment, allowing identification of the bacteria and fungi present.

TRFLP analyses will be performed on the Bioremediation Treatability Study Phase 1 soil samples and the results will be compared to analytical chemistry data and cultured bacteria and fungi from the same sampling locations. This comparison will determine the diversity of the microbial community. TRFLP analyses will also identify DNA analysis peaks that may be associated with known degraders of the COIs. The results of the TRFLP analyses will be included in a table that compares the microbial

population diversity between sample locations and indicates patterns found between genetic signatures and COIs present. The TRFLP SOP is presented as SSFL SOP ST BIO 2, *TRFLP Analysis*.

4.2.6 Metagenomics Analysis

The bacterial and fungal microbial communities in soil samples will also be characterized using a second-generation DNA sequencing method known as metagenomics. This approach will provide more detail about the genus and species-level bacteria and fungi present in the soils at Area IV (Maphosa et al 2012). Sandia has the capability to run this analysis and has agreed to provide these analyses for Area IV samples. DNA will be extracted from soil samples at Cal Poly using the same method as used for TRFLP analysis. The DNA will be quantified, packaged and shipped overnight to Sandia in Livermore, CA in a container with icepacks. The material will be shipped by courier service (rather than US Postal Service) to Sandia. A courier will be used to avoid material exposure to x-rays used by the US Postal Service. Sandia will amplify 16S rRNA genes for bacteria and 18S rRNA genes for fungi, and sequence them from each sample. The sequence data will be run through standard database analysis to identify microorganisms present and their relative abundance in soil samples with varying COI concentrations, including non- or less-contaminated soils, if available.

Since metagenomics provides identification of bacteria and fungi, the metagenomics results can be used to determine if known COI degraders are present in the Area IV soils. Also, an analysis of variance will be used to examine possible correlations between COI concentrations and the abundance of certain bacteria and/or fungi species. Strong correlations between COI concentrations and a species of bacteria or fungi may indicate that the microorganism is involved in biodegradation of that COI.

4.2.7 Chemical Evidence for Biodegradation

Biodegradation of the COIs results in the formation of intermediate and end-product compounds. Identification of these intermediate and end-product compounds can be used as evidence for biodegradation at Area IV. The following strategies will be used to provide possible lines of evidence for biodegradation for each of the COIs:

- *PCBs*: Identify shifts from highly chlorinated PCBs to less chlorinated PCBs. This strategy will be implemented during Phase 2 microcosm soil analyses.
- *Dioxins*: Identify shifts from highly chlorinated dioxins to less chlorinated dioxins using current *SSFL Data Gap Phase 3 Work Plan* chemical analyses (CDM Smith 2012a).
- *TPH*: Identify losses of alkanes and a shift to higher molecular-weight petroleum compounds. TPH analyses will include a "simulated distillation" method of integration using the standard equivalent carbon ranges analyzed for Data Gap Phase 3 soil sampling (C8-C11, C12-C14, C15-C20, C21-C30, and C30-C40). Chromatograms of the TPH chemical analyses will be obtained from the contract laboratory so that the presence/absence of alkane peaks can be observed, and alkanes can be identified.
- *PAH*: Identify a decrease in larger PAH molecules using current *SSFL Data Gap Phase 3 Work Plan* chemical analyses (CDM Smith 2012a).

4.3 Treatability Study Phase 2: Laboratory Microcosm Experiments

The following sections discuss the tasks associated with Phase 2 of the bioremediation treatability study. Phase 2 is a series of laboratory microcosm experiments. The laboratory microcosm experiments will determine site-specific biodegradation extents and rates for the COIs as well as the potential for biostimulation and/or bioaugmentation to increase these COI degradation rates and/or facilitate end-product degradation mechanisms.

4.3.1 Treatability Study Phase 2 Soil Sample Location Selection

Four sample locations within Area IV will be selected for sampling and use in the Phase 2 microcosms, provided that anaerobic soil conditions are found to be present at Area IV during field investigations. If anaerobic soil conditions are not found, three sample locations within Area IV will be selected for sampling. A one day field investigation will be conducted at locations within Area IV to test for the presence of anaerobic soil conditions in soils deeper than ten feet below the soil surface. This investigation will use a probe attached to a drill rig to collect soil vapor samples. These soil vapor samples will be analyzed to determine the oxygen content of these soils at depth. The number of locations sampled will be determined by the time required to conduct this sampling at each location. The final anaerobic sampling location will be determined after the results of this soil vapor field investigation.

Site selection criteria for the microcosm bulk soils were determined by a literature review of COI concentrations known to be toxic to microbial communities. Phase 2 soil samples will be collected from locations with COI concentrations below these toxic COI concentrations. The toxic COI concentrations are:

- Dioxin: approximately 100 mg/kg
- PAH: approximately 300 mg/kg
- PCBs: approximately 500 mg/kg
- TPH: approximately 44,000 mg/kg

The COI concentration criteria for Phase 2 soil sample locations are different from the criteria used for Phase 1 of this study. As previously described, Phase 1 will involve collecting soil samples with a range of COI concentrations. Phase 2 soil sample locations have been selected to avoid COI concentrations that are potentially toxic to the microorganisms. Historical COI concentration data for these sample locations were compared to the above concentration criteria to ensure that the soils would not have COI concentrations toxic to microorganisms.

Proposed Bioremediation Treatability Study Phase 2 soil sample locations are presented in Figure 4-2.

4.3.2 Treatability Study Phase 2 Soil Sample Collection

Sample locations will be screened for total organic vapors (per SSFL SOP 6, *Field Measurement of Total Organic Vapors*) and residual radiation (per SSFL SOP 7, *Field Measurement of Residual Radiation*) prior to sample collection. These and other applicable soil clearing, sampling, and handling procedure SOPs are contained in the *Data Gap Phase 3 Work Plan* (CDM Smith 2012b) and in Appendix D of this document. Candidate sample locations will also be chemically analyzed to ensure that bioremediation

treatability study samples are not taken from soils with COI concentrations exceeding federal or California regulatory levels for hazardous wastes, and that the soils meet the COI concentration criteria listed in this study plan (Section 4.3.1). Soil sampling will conform to procedures described in the *Data Gap Phase 3 Work Plan*.

Soil will be collected from the three aerobic study sample locations per the applicable Data Gap Phase 3 Work Plan SOPs, including field screening procedures. Approximately 68 kilogram (kg) of soil (52 kg from sample location 5C_DG-516, 8 kg from sample location 5C_DG-755, and 8 kg from sample location PUBS1044) will be collected per either SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger* or SSFL SOP 4, *Direct Push Technology (DPT) Sampling*.

Two of these three soil samples will be collected from a depth of 1 to 4 ft below the ground surface. One of these three soil samples will be collected from a depth of 4 to 5 ft below the ground surface. One additional soil sample location will have anaerobic conditions, if anaerobic soil conditions are found at Area IV during the soil vapor investigation. This soil sample will be targeted from a depth of 9 to 10 ft below ground surface, depending on the presence/existence of anaerobic soil conditions. This sample will be both stored in the field and transported to Cal Poly in an oxygen free environment (e.g., cooler containing dry ice), and stored in nitrogen gas at Cal Poly until the microcosms are prepared.

Aerobic soils will be homogenized per SSFL SOP ST PHY 9, *Bulk Soil Homogenization.* Aerobic Sample Location 2 soils will be homogenized per SSFL SOP ST PHY 6, *Field Homogenization of Soil Samples.* Anaerobic soils, if collected, will be homogenized per SSFL SOP 17, *Laboratory Homogenization For Phase 3 Soil Samples* in a nitrogen-purged glovebox at Cal Poly.

4.3.3 Microcosm Experimental Design and Operation

Microcosms are controlled environments. This study will have some microcosms that mimic certain conditions of Area IV, and some microcosms that will be operated under a variety of altered conditions to test for biostimulation and bioaugmentation potential. Additives to the microcosms will be analyzed by the contract laboratories for COIs using methods presented in Table 4-1. All additives, including deionized water for moisture adjustment, will only be added once, when the microcosms are first prepared.

Each microcosm will be a 4-liter glass jar filled with 1.4 kg of soil from the sample locations and sealed with a Teflon-lined lid to provide an air-tight seal (Figure 4-3). Soil moisture and approximate oxygen level will be controlled in the microcosms to simulate Area IV conditions. Aerobic microcosms will have the headspace in the jars filled with ambient air. The ambient air in the headspace will be sufficient to allow for aerobic soils to remain aerobic for the duration of the Phase 2 experiments. If anaerobic site conditions are found, then one set of microcosms will be operated under anaerobic conditions by preparing microcosms in an anaerobic glove box with nitrogen gas purge, and filling the headspace in the microcosm with nitrogen prior to sealing the jar with the lid.

Ten types of microcosms will be used in Phase 2, assuming anaerobic site conditions are present in Area IV soils. Five replicates of each microcosm type will be constructed, for a possible total of fifty microcosms. The nine possible microcosm types are presented in Table 4-4.

Microcosms will be operated in the Environmental Protection Engineering Laboratory of Cal Poly (Cal Poly Building 13, Room 114). Access to this laboratory is limited to Cal Poly researchers. Jars will be sealed and incubated at the soil temperature observed during soil collection. The different types of

microcosms and their operation are detailed in this section and SSFL SOP ST BIO 1, *Bioremediation Microcosm Preparation and Operation*.

All non-disposable equipment used in Cal Poly's laboratory experiments will be decontaminated per *SSFL SOP ST PHY 7, Laboratory Sampling Equipment Decontamination*. All Cal Poly experiment-derived waste will be handled per *SSFL ST BIO 3, Guide to Handling Bioremediation Treatability Experiment-Derived Waste*. Cal Poly researchers will document all laboratory procedures and observations per *SSFL SOP ST PHY 10, Cal Poly Laboratory Data Collection, Documents, Content, and Control*.

Table 4-4 Microcosm experimental design and operation

Amendment	Sterilized?	Soil Sample Location	Sample Intervals
No amendment	Sterilized	5C_DG-516	0, 4, and 9-months
No amendment	Unsterilized	5C_DG-516	0, 4, and 9-months
No amendment	Unsterilized	5C_DG-755	0, 4, and 9-months
No amendment	Unsterilized	PUBS1044	0, 4, and 9-months
No amendment	Unsterilized	Anaerobic sample location (conditional)	0, 4, and 9-months
Nutrient (Miracle-Gro)	Unsterilized	5C_DG-516	0, 4, and 9-months
Rice hulls	Unsterilized	5C_DG-516	0, 4, and 9-months
Rice hulls, nutrient, malt extract, and *P. chrysosporium* fungi	Unsterilized	5C_DG-516	0, 4, and 9-months
Biosurfactant (soya lecithin)	Unsterilized	5C_DG-516	0, 4, and 9-months
Biosurfactant, rice hulls, nutrient, malt extract, and *P. chrysosporium fungi*	Unsterilized	5C_DG-516	0, 4, and 9-months

4.3.3.1 Unamended Soils from Aerobic Sample Locations

Fifteen unamended aerobic microcosms will be used to determine baseline aerobic COI degradation extents and rates (i.e., natural attenuation processes) for Area IV. The 15 microcosms will not be sterilized, will not be bioaugmented, and will not have nutrients, biosurfactants, or rice hulls added. Five of the unamended microcosms will have soil from sample location 5C_DG-516, five of the unamended microcosms will have soil from sample location 5C_DG-755, and five of the unamended microcosms will have soil from sample location PUBS1044. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

4.3.3.2 Unamended Soils from Anaerobic Sample Location (conditional)

Five unamended anaerobic microcosms will be used to determine baseline anaerobic COI degradation extents and rates (i.e., natural attenuation processes) for Area IV, if soils are found to be anaerobic during the soil vapor investigation. The five microcosms will not be sterilized, will not be bioaugmented, and will not have nutrients, biosurfactants, or rice hulls added. The five microcosms will have soil from the anaerobic sampling location. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses

after 0, 4, and 9 months of operation. These anaerobic soils will be homogenized by Cal Poly in a nitrogen-filled glove box prior to the soils being placed in the microcosms.

4.3.3.3 Sterilized Control

Five sterilized microcosms will be used to determine degradation extents and rates for unamended soils in which no microbial activity is occurring. The soils used for these microcosms will be sterilized by a licensed contract laboratory using a Cobalt-60 source for gamma irradiation. These microcosms will test for potential abiotic contaminant losses during incubation of the microcosms. These five microcosms will contain soil from sample location 5C_DG-516. The five microcosms will not be bioaugmented, and will not have nutrients, biosurfactants, or rice hulls added. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

4.3.3.4 Biosurfactant Amendment

Five aerobic microcosms will be used to determine if the addition of a biosurfactant to Area IV soils can increase biodegradation rates of the soil COIs. The five microcosms will not be sterilized, will not be bioaugmented, and will not have nutrients or rice hulls added. De-oiled soya lecithin granules will be added to the microcosm soils at 1.5% weight/weight. These five microcosms will have soil from sample location 5C_DG-516. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

4.3.3.5 Nutrient Amendment

Five aerobic microcosms will be used to determine if the addition of nutrients to Area IV soils can increase biodegradation rates of the soil COIs. The five microcosms will not be sterilized, will not be bioaugmented, and will not have biosurfactants or rice hulls added. Miracle-Gro All-Purpose Plant Food will be added to the microcosm soils at the equivalent of 5.1 milligram (mg) nitrogen per kg of soil. The five microcosms will have soil from sample location 5C_DG-516. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

4.3.3.6 Rice Hull Amendment

Five aerobic microcosms will be used to determine if the addition of rice hulls to Area IV soils can increase biodegradation rates of the soil COIs. Rice hulls may aid in biodegradation of contaminants through increased soil aeration and/or serve as a supplemental carbon source for native bacteria and/or fungi. The five microcosms will not be sterilized, will not be bioaugmented, and will not have biosurfactants or nutrients added. Rice hulls will be added to these microcosm soils at a ratio of 10% weight/weight. The five microcosms will have soil from sample location 5C_DG-516. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

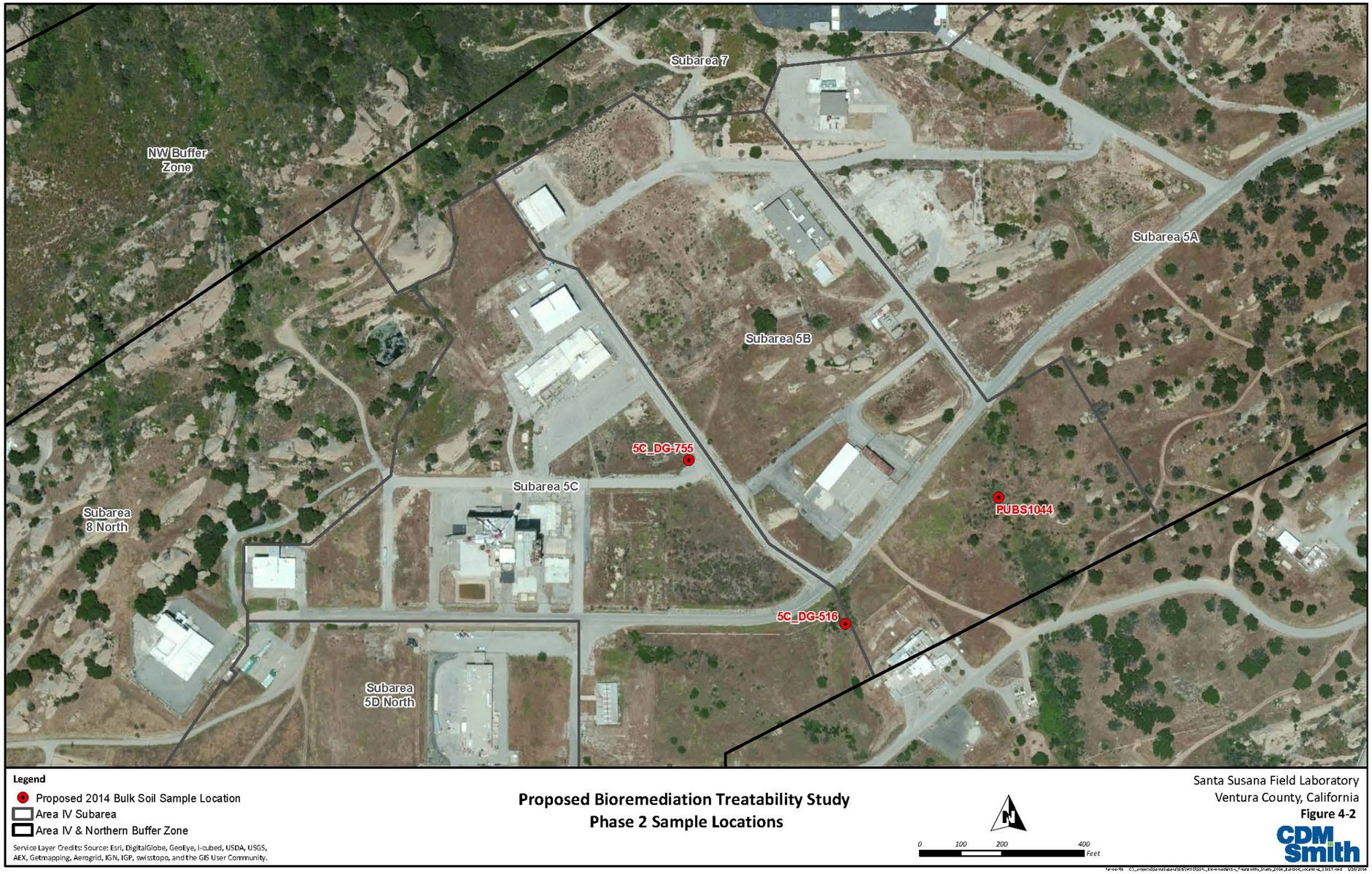

Figure 4-2: Proposed Bioremediation Treatability Study Phase 2 Sample Locations

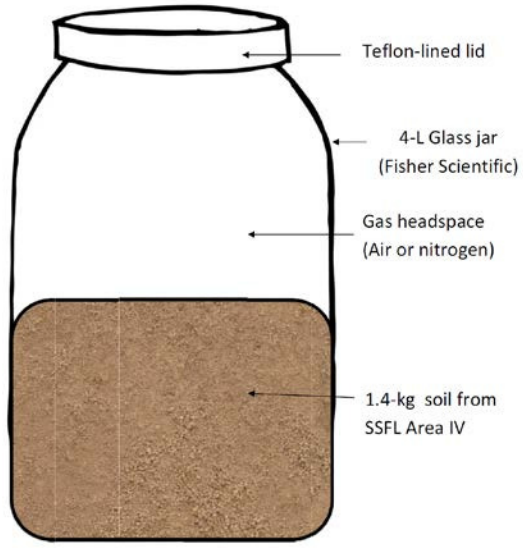

Figure 4-3 Bioremediation Treatability Soil Microcosms

4.3.3.7 Bioaugmentation with P. chrysosporium

Five aerobic microcosms will be used to determine if bioaugmentation can increase biodegradation rates and/or facilitate end-product degradation mechanisms of the Area IV soil COIs. The five microcosms will not be sterilized and will not have biosurfactants added. Freeze-dried P. chrysosporium will be inoculated on rice hulls with 50 mL of inoculant solution (contents are outlined below) and added to the bioaugmentation microcosms. The inoculant solution ensures that adequate carbon, nitrogen, and phosphorus are provided for microbial growth. The total mass of rice hulls added will be the same as that added to the rice-hull only microcosms (10% weight/weight). The five microcosms will have soil from sample location 5C_DG-516. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

Media on which P. chrysosporium is grown will contain:

- 2.0 g/L KH_2PO_4
- 0.3 g/L $MgSO_4{\cdot}7H_2O$
- 0.4 g/L $CaCl_2{\cdot}2H_2O$
- $NaNO_3$ (quantity to be determined based on carbon, nitrogen, and phosphorus concentrations in the microcosm soil samples)
- 3 g/L malt extract

4.3.3.8 Combined Amendments

Five aerobic microcosms will be used to determine if a combination of the above amendments can increase biodegradation rates and/or facilitate end-product degradation mechanisms of the Area IV soil COIs. The five microcosms will not be sterilized. The microcosms will be augmented with all of the

aforementioned augmentation materials (1.5% weight/weight soya lecithin, Miracle-Gro, and a 10% weight/weight rice hull mixture containing 50% weight/weight P. chyrsosporium-augmented hulls). The five microcosms will have soil from sample location 5C_DG-516. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

4.3.4 Collaboration with Other Treatability Studies

The bioremediation study will be able to provide valuable information to the other soil treatability studies being conducted. Listed below are opportunities for the bioremediation project to inform these other treatability studies:

1. Biodegradation extents and rates in unamended microcosms will inform the natural attenuation study for the estimation of biodegradation extents and rates which could be expected at Area IV under current conditions.

2. Biodegradation extents and rates observed in the bioremediation microcosms can be combined with those observed in the phytoremediation microcosms to provide a larger, more reliable set of results for determining biodegradation mechanisms and rates occurring and/or potentially achievable at Area IV.

4.3.5 Study Limitations

The biodegradation rates of some of the COIs, especially PCBs and dioxins, may be very slow. The time frame of the Phase 2 microcosm experiments may not be long enough to observe significant changes in the concentrations of these COIs. However, these microcosm experiments will still be useful because they can provide information of the limited biodegradation rates possible for these COIs.

4.4 Health and Safety Requirements

Health and safety requirements for activities in the field will follow procedures from the Worker Safety and Health Program for Chemical Data Gap Investigation Phase 3 Soil Chemical Sampling at Area IV, Santa Susana Field Laboratory, Ventura County, California (CDM Smith 2012a).

Health and safety requirements for activities in the Cal Poly laboratory will follow applicable Cal Poly procedures.

4.5 Quality Assurance/Quality Control Requirements

Field sampling and analytical methods will follow procedures from the QAPP outlined in the Master Field Sampling Plan for Chemical Data Gap Investigation, Phase 3 Soil Chemical Sampling at Area IV, Santa Susana Field Laboratory; Ventura County, California; April 2012 (CDM Smith 2012b). These procedures were approved for other studies that have been or will be conducted at SSFL (Phase 3 QAPP). Routine analytical procedures will be based on the Phase 3 QAPP. Quality control objectives are presented in Appendix B.

Section 5

Study Report Description

The study report will detail the methodologies used in this treatability study, deviations from this plan (if any), present the chemical data from the contract laboratories' analyses and Cal Poly's own experiments, and provide recommendations for use of the information in other treatability studies. The report will also provide suggestions for follow-up studies, if warranted, and insights into how the information generated by this study could impact remediation efforts within Area IV. The study report will be completed after relevant data have been reviewed and analyzed.

The draft study report will be prepared by Cal Poly and CDM Smith. DOE and DTSC will subsequently review the draft report and provide suggested comments and edits. Cal Poly and CDM Smith will revise the study report accordingly and provide DOE and DTSC with a second draft of the report for their review. CDM Smith will then incorporate any necessary changes and provide a finalized version of the report, incorporating any necessary changes, to DTSC for approval.

CDM Smith will also prepare a comprehensive soil treatability evaluation report that will discuss the results of the five soil treatability studies and their implications. The structure of the comprehensive soil treatability evaluation report is presented in the Master Work Plan (CDM Smith 2013).

The bioremediation soil treatability study report will be structured as follows:

1. Introduction
    a. Purpose of study
    b. Summarized conclusions
2. Roles and responsibilities of study team
3. Basis of studies
    a. Study objectives
    b. Study phases
    c. Study limitations
4. Study materials and methods
    a. Background information/literature review and observations
    b. Field activities and observations
    c. Laboratory activities and observations
    d. Analytical procedures/chemical analyses and observations
    e. Health and safety requirements and observations
    f. Quality assurance/quality control requirements and observations
5. Study findings
    a. Data presentation
    b. Data review and discussion
6. Conclusions
    a. Implications for natural attenuation and bioremediation of SSFL soils
    b. Implications for other studies
    c. Recommendations
7. References

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Section 6

Study Schedule

TASK	2013	2014			
	Quarter 4	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Develop study plan and standard operating procedures					
Literature review					
Study plan review					
Phase 1 field sampling for microbial assays					
Phase 1 microbe isolation and genetic sequencing analysis					
Literature review of isolated microbes					
Phase 2 laboratory microcosm operation					
Data analysis and interpretation					
Study report					

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Section 7
Study References

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Appendix A

Analytical Method Reporting Limits

Modified from *CDM Smith. (2012). "Data Gap Work Plan QAPP For Chemical Data Gap Investigation Phase 3 Soil Chemical Sampling at Area IV, Santa Susana Field Laboratory, Ventura County, CA." Prepared for Department of Energy, Energy Technology and Engineering Center. April.*

Modifications to the Data Gap Work Plan QAPP include the addition of soil analyses for total nitrogen and organic carbon.

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Analytical Method Reporting Limits

Analyte	Soils		Waters	
	Reporting Limit	Unit	Reporting Limit	Unit
Dioxins/Furans by EPA Method 1613B				
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	8.1	ng/kg	20	pg/L
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	140	ng/kg	20	pg/L
1,2,3,4,6,7,8-Heptachlorodibenzofuran	2.5	ng/kg	10	pg/L
1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	13	ng/kg	10	pg/L
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.19	ng/kg	10	pg/L
1,2,3,4,7,8-Hexachlorodibenzofuran	0.73	ng/kg	10	pg/L
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.34	ng/kg	10	pg/L
1,2,3,6,7,8-Hexachlorodibenzofuran	0.3	ng/kg	10	pg/L
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.95	ng/kg	10	pg/L
1,2,3,7,8,9-Hexachlorodibenzofuran	0.43	ng/kg	10	pg/L
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1.1	ng/kg	10	pg/L
1,2,3,7,8-Pentachlorodibenzofuran	0.59	ng/kg	10	pg/L
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	0.18	ng/kg	10	pg/L
2,3,4,6,7,8-Hexachlorodibenzofuran	0.45	ng/kg	10	pg/L
2,3,4,7,8-Pentachlorodibenzofuran	0.64	ng/kg	10	pg/L
2,3,7,8-Tetrachlorodibenzofuran	1.8	ng/kg	2	pg/L
2,3,7,8-Tetrachlorodibenzo-p-dioxin	0.5	ng/kg	2	pg/L
TCDD TEQ[9]	0.87	ng/kg	2	pg/L
Metals by EPA Method 6010C/6020A				
Aluminum	20000	mg/kg	0.2	mg/L
Antimony	8.7	mg/kg	0.001	mg/L
Arsenic	15	mg/kg	0.002	mg/L
Barium	140	mg/kg	0.002	mg/L
Beryllium	1.1	mg/kg	0.0005	mg/L
Boron	9.7	mg/kg	0.05	mg/L
Cadmium	1	mg/kg	0.0005	mg/L
Calcium	20	mg/kg	0.2	mg/L
Chromium	36.8	mg/kg	0.002	mg/L
Cobalt	21	mg/kg	0.0005	mg/L
Copper	29	mg/kg	0.002	mg/L
Iron	28000	mg/kg	0.2	mg/L
Lead	34	mg/kg	0.001	mg/L
Lithium	37	mg/kg	0.02	mg/L
Magnesium	10	mg/kg	0.1	mg/L
Manganese	495	mg/kg	0.005	mg/L
Molybdenum	5.3	mg/kg	0.0005	mg/L
Nickel	29	mg/kg	0.002	mg/L
Phosphorus	10	mg/kg	0.1	mg/L
Potassium	6400	mg/kg	0.5	mg/L
Selenium	0.655	mg/kg	0.002	mg/L
Silver	0.79	mg/kg	0.0005	mg/L
Sodium	110	mg/kg	1	mg/L
Strontium	0.495	mg/kg	0.005	mg/L
Thallium	0.46	mg/kg	0.0005	mg/L
Tin	10.9	mg/kg	0.02	mg/L
Titanium	0.995	mg/kg	0.01	mg/L
Vanadium	62	mg/kg	0.0005	mg/L
Zinc	110	mg/kg	0.015	mg/L
Zirconium	8.6	mg/kg	0.05	mg/L
Nitrogen by ASTM D5373				
Total Nitrogen	0.5	%	0.5	%
Organic Carbon by Standard Method (SM) 5310				
Organic Carbon	1	mg/kg	1	mg/L
Mercury by EPA Method 7471B/7470A/3200				
Mercury	0.09	mg/kg	0.0002	mg/L
Methyl Mercury by EPA Method 1630				
Methyl Mercury	0.12	pg/g	0.06	ng/L

Analytical Method Reporting Limits

Analyte	Soils		Waters	
	Reporting Limit	Unit	Reporting Limit	Unit
Miscellaneous Analyses				
Percent Moisture (D2216)	0.1	%	NA	NA
pH (9040C and 9045D)	8.86	pH	0.01	pH
PCBs and PCTs by EPA Method 8082A				
Aroclor 1016	20.5	µg/kg	0.5	µg/L
Aroclor 1221	20.5	µg/kg	0.5	µg/L
Aroclor 1232	20.5	µg/kg	0.5	µg/L
Aroclor 1242	20.5	µg/kg	0.5	µg/L
Aroclor 1248	20.5	µg/kg	0.5	µg/L
Aroclor 1254	20.5	µg/kg	0.5	µg/L
Aroclor 1260	20.5	µg/kg	0.5	µg/L
Aroclor 1262	7.7	µg/kg	0.5	µg/L
Aroclor 1268	7.7	µg/kg	0.5	µg/L
Aroclor 5432	51.6	µg/kg	0.5	µg/L
Aroclor 5442	51.6	µg/kg	0.5	µg/L
Aroclor 5460	77	µg/kg	0.5	µg/L
Polynuclear Aromatic Hydrocarbons (PAHs) and NDMA (8270C/D SIM)				
1-Methylnaphthalene	21.1	µg/kg	0.05	µg/L
2-Methylnaphthalene	21.1	µg/kg	0.05	µg/L
Acenaphthene	21.1	µg/kg	0.05	µg/L
Acenaphthylene	21.1	µg/kg	0.05	µg/L
Anthracene	21.1	µg/kg	0.05	µg/L
Benzo(a)anthracene	19.9	µg/kg	0.05	µg/L
Benzo(a)pyrene	21.1	µg/kg	0.05	µg/L
Benzo(b)fluoranthene	21.1	µg/kg	0.05	µg/L
Benzo(g,h,i)perylene	21.1	µg/kg	0.05	µg/L
Benzo(k)fluoranthene	20.4	µg/kg	0.05	µg/L
Chrysene	21.3	µg/kg	0.05	µg/L
Dibenz(a,h)anthracene	20	µg/kg	0.05	µg/L
Fluoranthene	20.5	µg/kg	0.05	µg/L
Fluorene	21.1	µg/kg	0.05	µg/L
Indeno(1,2,3-cd)pyrene	21.3	µg/kg	0.05	µg/L
Naphthalene	21.1	µg/kg	0.05	µg/L
Phenanthrene	21.1	µg/kg	0.05	µg/L
Benzo(e)pyrene	1.96	µg/kg	5	µg/L
N-Nitrosodimethylamine	25	µg/kg	0.05	µg/L
Benzo(a)pyrene [BaP] TEQ	21.1	µg/kg	0.05	µg/L
TPH by EPA Method 8015B/C/D				
EFH (C12-C14)	5.05	mg/kg	0.6	mg/L
EFH (C15-C20)	5.09	mg/kg	0.6	mg/L
EFH (C21-C30)	5.09	mg/kg	0.6	mg/L
EFH (C30-C40)	1.4	mg/kg	0.6	mg/L
EFH (C8-C11)	5.05	mg/kg	0.6	mg/L

DRO - diesel range organics
EFH – extractable fuel hydrocarbons
EPA - United States Environmental Protection Agency
GRO - gasoline range organics
mg/kg - milligrams per kilogram
mg/L - milligrams per liter
ng/kg - nanograms per kilogram
ng/L - nanograms per liter
pg/L – picogram per liter
µg/L – microgram per liter
* - 1,2 dimethylhydrazine is very unstable, monitoring for this compound using azobenzene.
** - These compounds are tentatively identified compound (TICs) quantified using a single point calibration.
-- = no value

Appendix B

Quality Control Objectives for Analytical Methods

Modified from *CDM Smith. (2012). "Data Gap Work Plan QAPP For Chemical Data Gap Investigation Phase 3 Soil Chemical Sampling at Area IV, Santa Susana Field Laboratory, Ventura County, CA." Prepared for Department of Energy, Energy Technology and Engineering Center. April.*

Modifications to the Data Gap Work Plan QAPP include the addition of soil analyses for total nitrogen and organic carbon.

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Quality Control Objectives for Analytical Methods

Analytical Category	Method Number and Reference	MS/MSD or Surrogate Accuracy Criterion (% Recovery)		BS/LCS Accuracy Criterion (% Recovery)		Precision Criterion (Maximum RPD)	
		Soil	Water	Soil	Water	Soil	Water
pH	**EPA Method 9040C/9045D**						
pH		NA	NA	95-105	90-110	5	
TPH	**EPA Method 8015B/C/D**						
EFH (C12-C14)		—	—	—	—	—	—
EFH (C15-C20)		—	—	—	—	—	—
EFH (C21-C30)		—	—	—	—	—	—
EFH (C30-C40)		—	—	—	—	—	—
EFH (C8-C11)		—	—	—	—	—	—
Polychlorinated biphenyls and PCTs	**EPA Method 8082A**						
Aroclor 1016		—	—	—	—	—	—
Aroclor 1221		—	—	—	—	—	—
Aroclor 1232		—	—	—	—	—	—
Aroclor 1242		—	—	—	—	—	—
Aroclor 1248		—	—	—	—	—	—
Aroclor 1254		—	—	—	—	—	—
Aroclor 1260		—	—	—	—	—	—
Aroclor 1262		—	—	—	—	—	—
Aroclor 1268		—	—	—	—	—	—
Aroclor 5432		—	—	—	—	—	—
Aroclor 5442		—	—	—	—	—	—
Aroclor 5460		—	—	—	—	—	—
Surrogate		—	—	—	—	—	—
Decachlorobiphenyl		45-120	45-120	45-120	45-120	NA	NA
Metals	**EPA Method 6010 C/6020A**						
Aluminum		75-125	75-125	—	80-120	20	
Antimony		75-125	75-125	—	80-120	20	
Arsenic		75-125	75-125	—	80-120	20	
Barium		75-125	75-125	—	80-120	20	
Beryllium		75-125	75-125	—	80-120	20	
Cadmium		75-125	75-125	—	80-120	20	
Calcium		75-125	75-125	—	80-120	20	
Chromium		75-125	75-125	—	80-120	20	
Cobalt		75-125	75-125	—	80-120	20	
Copper		75-125	75-125	—	80-120	20	
Iron		75-125	75-125	—	80-120	20	
Lead		75-125	75-125	—	80-120	20	
Magnesium		75-125	75-125	—	80-120	20	
Manganese		75-125	75-125	—	80-120	20	
Nickel		75-125	75-125	—	80-120	20	
Potassium		75-125	75-125	—	80-120	20	
Selenium		75-125	75-125	—	80-120	20	
Silver		75-125	75-125	—	80-120	20	

Quality Control Objectives for Analytical Methods

Analytical Category	Method Number and Reference	MS/MSD or Surrogate Accuracy Criterion (% Recovery)		BS/LCS Accuracy Criterion (% Recovery)		Precision Criterion (Maximum RPD)	
		Soil	Water	Soil	Water	Soil	Water
Sodium		75-125	75-125	—	80-120	20	
Thallium		75-125	75-125	—	80-120	20	
Vanadium		75-125	75-125	—	80-120	20	
Zinc		75-125	75-125	—	80-120	20	
Miscellaneous Analyses							
Percent Moisture	D2216	—	—	—	—	—	
pH	9040C and 9045D	—	—	—	—	—	—
Total Nitrogen	ASTM D5373	75-125	75-125	—	80-120	20	
Organic Carbon	Standard Methods (SM) 5310	75-125	75-125	—	80-120	20	
Dioxins/Furans	**EPA Method 1613B**						
2,3,7,8-TCDD		40-135	40-135	67-158	60-150	20	
1,2,3,7,8-PeCDD		40-135	40-135	70-142	60-150	20	
1,2,3,4,7,8-HxCDD		40-135	40-135	70-164	60-150	20	
1,2,3,6,7,8-HxCDD		40-135	40-135	76-134	60-150	20	
1,2,3,7,8,9-HxCDD		40-135	40-135	64-162	60-150	20	
1,2,3,4,6,7,8-HpCDD		40-135	40-135	70-140	60-150	20	
OCDD		40-135	40-135	78-144	60-150	20	
2,3,7,8-TCDF		40-135	40-135	75-158	60-150	20	
1,2,3,7,8-PeCDF		40-135	40-135	80-134	60-150	20	
2,3,4,7,8-PeCDF		40-135	40-135	68-160	60-150	20	
1,2,3,4,7,8-HxCDF		40-135	40-135	72-134	60-150	20	
1,2,3,6,7,8-HxCDF		40-135	40-135	84-130	60-150	20	
2,3,4,6,7,8-HxCDF		40-135	40-135	70-156	60-150	20	
1,2,3,7,8,9-HxCDF		40-135	40-135	78-130	60-150	20	
1,2,3,4,6,7,8-HpCDF		40-135	40-135	82-122	60-150	20	
1,2,3,4,7,8,9-HpCDF		40-135	40-135	78-138	60-150	20	
OCDF		40-135	40-135	63-170	60-150	20	
Mercury	**EPA Method 7471B/7470A**						
Mercury		65-135	75-125	85-120	90-115	20	
Methyl Mercury	**EPA Method 1630**						
Methyl mercury		70-130	75-125	70-130	77-123	30	25
PAH	**EPA Method 8270C/D SIM**						
Acenaphthene		—	—	—	—	—	—
Acenaphthylene		—	—	—	—	—	—
Anthracene		—	—	—	—	—	—
Benzo(a)anthracene		—	—	—	—	—	—
Benzo(a)pyrene		—	—	—	—	—	—
Benzo(b)fluoranthene		—	—	—	—	—	—
Benzo(g,h,i)perylene		—	—	—	—	—	—
Benzo(k)fluoranthene		—	—	—	—	—	—
Chrysene		—	—	—	—	—	—
Dibenzo(a,h)anthracene		—	—	—	—	—	—

Quality Control Objectives for Analytical Methods

Analytical Category	Method Number and Reference	MS/MSD or Surrogate Accuracy Criterion (% Recovery)		BS/LCS Accuracy Criterion (% Recovery)		Precision Criterion (Maximum RPD)	
		Soil	Water	Soil	Water	Soil	Water
Fluoranthene		—	—	—	—	—	—
Fluorene		—	—	—	—	—	—
Indeno(1,2,3-cd)pyrene		—	—	—	—	—	—
n-Nitrosodimethylamine		—	—	—	—	—	—
Naphthalene		—	—	—	—	—	—
Phenanthrene		—	—	—	—	—	—
Pyrene		—	—	—	—	—	—
1-Methylnaphthalene		—	—	—	—	—	—
2-Methylnaphthalene		—	—	—	—	—	—
Surrogates							
Phenol-d5		25-120	20-120	25-120	20-110	NA	NA
2-Fluorophenol		25-130	20-130	25-130	20-110	NA	NA
2,4,6-Tribromophenol		35-130	30-130	35-130	30-110	NA	NA
Nitrobenzene-d5		40-130	40-130	40-130	40-130	NA	NA
2-Fluorbiphenyl		45-130	45-130	45-130	45-130	NA	NA
Terphenyl-d14		45-135	45-135	45-130	45-130	NA	NA

Acronyms and Abbreviations:

BFB = Bromofluorobenzene
BS/LCS = Blank Spike/Laboratory Control Sample
EPA = U.S. Environmental Protection Agency
MS/MSD = Matrix Spike/Matrix Spike Duplicate
NA = not applicable
RPD = Relative Percent Difference
PAH = polycyclic aromatic hydrocarbons
SIM = selected ion monitoring
"—" = Laboratory-specific lower control limit-upper control limit or laboratory specific maximum RPD

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Appendix C

AOC Chemical Look-Up Table Values

AOC Chemical Look-Up Table values provided for informational purposes.

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AOC Chemical Look-up Table Values (6/11/2013)

Chemical Class	Chemical Name	CAS #	Analytical Method	Look-up Table Value (06/11/2013)	Units
PAH	1-Methyl naphthalene	90120	EPA 8270	2.5	µg/kg
	2-Methylnaphthalene	91576	EPA 8270	2.5	µg/kg
	Acenaphthene	83329	EPA 8270	2.5	µg/kg
	Acenaphthylene	208968	EPA 8270	2.5	µg/kg
	Anthracene	120127	EPA 8270	2.5	µg/kg
	Benzo(ghi)perylene	191242	EPA 8270	2.5	µg/kg
	Fluoranthene	206440	EPA 8270	5.2	µg/kg
	Fluorene	86737	EPA 8270	3.8	µg/kg
	Naphthalene	91203	EPA 8270	3.6	µg/kg
	Phenanthrene	85018	EPA 8270	3.9	µg/kg
	Pyrene	129000	EPA 8270	5.6	µg/kg
	BaP TEQ	BaP TEQ	EPA 8270	4.47	µg/kg
PCB	Aroclor 1016	12674112	EPA 8082	17	µg/kg
	Aroclor 1221	11104282	EPA 8082	33	µg/kg
	Aroclor 1232	11141165	EPA 8082	17	µg/kg
	Aroclor 1242	53469219	EPA 8082	17	µg/kg
	Aroclor 1248	12672296	EPA 8082	17	µg/kg
	Aroclor 1254	11097691	EPA 8082	17	µg/kg
	Aroclor 1260	11096825	EPA 8082	17	µg/kg
	Aroclor 1262	37324235	EPA 8082	33	µg/kg
	Aroclor 1268	11100144	EPA 8082	33	µg/kg
Perchlorate	Perchlorate	14797730	EPA 6850/6860	1.63	µg/kg
Dioxin	2,3,7,8-TCDD TEQ	1746016-TEQ	EPA 1613	0.912	ng/kg
Mercury	Mercury	7439976	EPA 7471	0.13	mg/kg
Methyl Mercury	Methyl Mercury	22967926	1630 (Mod)	0.05	µg/kg
TPH	Gasoline (C4-C12)	GROC5C12	EPA 8015	- -	mg/kg
	EFH(C8-C11)	PHCC8C11	EPA 8015	- -	mg/kg
	EFH(C12-C14)	PHCC12C14	EPA 8015	- -	mg/kg
	EFH(C15-C20)	PHCC15C20	EPA 8015	5	mg/kg
	EFH(C21-C30)	PHCC21C30	EPA 8015	- -	mg/kg
	Oil (C30-C40)	PHCC30C40	EPA 8015	- -	mg/kg

Chemical Class	Chemical Name	CAS #	Analytical Method	Look-up Table Value (06/11/2013)	Units
Metals	Aluminum	7429905	EPA 6010/6020	58,600	mg/kg
	Antimony	7440360	EPA 6010/6020	0.86	mg/kg
	Arsenic	7440382	EPA 6010/6020	46	mg/kg
	Barium	7440393	EPA 6010/6020	371	mg/kg
	Beryllium	7440417	EPA 6010/6020	2.2	mg/kg
	Boron	7440428	EPA 6010/6020	34	mg/kg
	Cadmium	7440439	EPA 6010/6020	0.7	mg/kg
	Chromium	7440473	EPA 6010/6020	94	mg/kg
	Cobalt	7440484	EPA 6010/6020	44	mg/kg
	Copper	7440508	EPA 6010/6020	119	mg/kg
	Lead	7439921	EPA 6010/6020	49	mg/kg
	Lithium	7439932	EPA 6010/6020	91	mg/kg
	Manganese	7439965	EPA 6010/6020	1,120	mg/kg
	Molybdenum	7439987	EPA 6010/6020	3.2	mg/kg
	Nickel	7440020	EPA 6010/6020	132	mg/kg
	Potassium	7440097	EPA 6010/6020	14,400	mg/kg
	Selenium	7782492	EPA 6010/6020	1	mg/kg
	Silver	7440224	EPA 6010/6020	0.2	mg/kg
	Sodium	7440235	EPA 6010/6020	1,780	mg/kg
	Strontium	7440246	EPA 6010/6020	163	mg/kg
	Thallium	7440280	EPA 6010/6020	1.2	mg/kg
	Vanadium	7440622	EPA 6010/6020	175	mg/kg
	Zinc	7440666	EPA 6010/6020	215	mg/kg
	Zirconium	7440677	EPA 6010/6020	19	mg/kg

Appendix D

Identified Data Gap Work Plan Phase 3 SOPs

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Procedures for Locating and Clearing Phase 3 Samples

SSFL SOP 1
Revision: 1
Date: July 2013

Prepared: P. Hartman
Technical Review: C. Werden
QA Review: J. Oxford
Approved and Issued: *Signature/Date*

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to describe the sample location and utility clearance protocols for the Phase 3 - Chemical Data Gap Investigation at the Santa Susana Field Laboratory (SSFL) site. Because this phase of investigation is targeted at minimizing data gaps in the understanding of the nature and extent of chemical contaminants in surface (0 to 0.5 foot) and subsurface (0.5 to 20 feet) soil, the precise location of each soil sample location is very important.

2.0 Background

2.1 Definitions

Data Gap Analysis–An analysis that identifies specific soil sample locations and depths for which insufficient data exists. The analysis is to minimize the data gap and ensure that collected data are representative of the study area. MWH, Inc. (MWH; under a separate agreement with Department of Energy [DOE]) is performing this effort.

Staked Location–Proposed sample location marked on the ground surface either with fluorescent paint (on concrete or asphalt), metal pins with fluorescent nylon whiskers, or wooden stakes marked with the sample location identifier installed at the exact sample locations identified through the MWH data gap analysis.

GPS– Global Positioning System that measures east-west and north-south coordinates of sample locations.

GeoExplorer 6000 Series Handheld Unit–GPS field unit used to survey proposed and actual sample locations.

Utility Locate–A survey of all proposed sample locations for underground utilities, including, but not limited to, water lines, sewer lines, storm sewer lines, gas lines, electric lines, and telecommunication lines. Performed by subcontractor.

Fisher TW-6-M-Scope Pipe and Cable Locator (or equivalent)-A field unit used to identify detectable electrically conductive conduits or piping which may have no surface expression.

Radiodetection RD4000 Utility Locator (or equivalent)-A field unit used to locate the surface trace of a variety of buried utilities.

Metrotech 50/60 Power Line Locator (or equivalent)–A field unit used to detect conduits that carry 60-cycle current.

3M Dynatel 2250 Cable Locator (or equivalent)-A field unit used to detect the surface trace of telephone and other narrow gauge wiring.

2.2 Associated Procedures

- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology (DPT) Sampling*
- SSFL SOP 5, *Backhoe Trenching/Test Pits for Sample Collection*
- SSFL SOP 6, *Field Measurement of Total Organic Vapor*
- SSFL SOP 7, *Field Measurement of Residual Radiation*
- SSFL SOP 8, *Field Data Collection Documents, Content, and Control*
- SSFL SOP 14, *Geophysical Survey*

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- SSFL SOP 16, *Control of Measurement and Test Equipment*

2.3 Discussion

Geographic Information System (GIS) sample location files will be received from MWH for field verification and those locations staked using global GPS location identification procedures. Office and field verification of GPS coordinates is necessary for determining the precise location of each sample point and to ensure the adequacy of signal strength of the GPS equipment. Inaccessible locations due to underground utilities, site geology, or that do not target the identified site will be assigned alternate locations by CDM Smith. Using GPS, site coordinate data will be collected at the alternative location and the updated surveyed location data will be electronically provided to MWH for updating the Area IV GIS. All proposed sample locations will be marked in the field using fluorescent paint, metal pins, or wooden stakes. Following MWH review of the relocated marked sample locations, CDM Smith will complete any additional required utility/geophysics clearances of the sample location and initiate sampling. In addition, protection of cultural and natural resources is an integral portion of locating sample points. Cultural, biological, and Native American monitors will be engaged throughout the process. Quality control measures will be implemented during GPS field collection and during post processing of confirmed or relocated sample locations. Staff responsible for GPS field collection will receive training on data collection and handling of data files that will be documented in a logbook.

3.0 General Responsibilities

Field Team Leader - The field team leader (FTL) is responsible for ensuring that field personnel collect soil and sediment samples in accordance with this SOP and other relevant procedures.

Site Health and Safety Technician– The person who will use field screening instruments to monitor all field activities for VOCs and radiological contaminants and pre-shipment sample coolers. This person is a trained radiological technician who works under the guidance of Science Application International Corporation's (SAIC's) Certified Health Physicist (CHP).

Site Geologist – The person responsible for attending sample location efforts and collecting and logging the soil sample.

Utility Locator Subcontractor – The subcontractor is responsible for identifying all buried utilities in the vicinity of soil borings, trenches, and test pits.

4.0 Required Equipment

4.1 General

- Site-specific plans (e.g., Field Sampling Plan [FSP] Addendum, health and safety)
- Mapping of proposed sample locations
- Mapping of known utilities
- Fluorescent paint and metal pins or wooden stakes
- Field logbook
- 2-way radios
- Monitoring and screening instruments per the health and safety plan
- 3M Dynatel 2250 Cable Locator (or equivalent) to detect the surface trace of telephone and other narrow gauge wiring
- Fisher TW-6-M-Scope Pipe and Cable Locator (or equivalent)
- Radiodetection RD4000 Utility Locator (or equivalent)
- Metrotech 50/60 Power Line Locator (or equivalent) to detect conduits that carry 60-cycle current
- GeoExplorer 6000 Series Handheld GPS Unit
- Sample rationale table (Table 1 of FSP Addendum)

5.0 Procedures

5.1 Field Staking

1. MWH provides specific data gap sample location information (i.e., GIS coordinates, map, and table) to CDM Smith for field use. The sample information includes:
   - Sample rationale (sampling objective)
   - Sample location
   - Depth interval
   - Analytical suite

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2. The figures showing proposed sample locations are provided to the cultural, biological, and Native American monitors in advance of field verification so they can review their records for any cultural or biological resources in the vicinity of the sampling areas.

3. A minimum of four working days advanced notice of field work is required for the cultural and biological resource reviews. CDM Smith will meet with the monitors to discuss concerns. Sample locations in areas of resource concern are reported back to CDM Smith and revised sample locations are discussed with DOE, the California Department of Toxic Substances Control (DTSC) and MWH.

4. Once all locations have been reviewed, the GIS sample location coordinates are loaded into the GPS (See Section 5.2) for field staking.

5. CDM Smith's Sample Location Team mobilizes to each proposed sampling location. This Team consists of:
   - CDM Smith's FTL/Geologist
   - CDM Smith Site Health and Safety Technician
   - Utility Location Technician
   - Science Applications International Corporation's (SAIC's) Archaeological/Cultural Resource Compliance representative
   - SAIC's Natural Resource Compliance representative
   - Native American monitor

6. The FTL locates each sample station using the GPS. The FTL verifies that the location addresses the sampling rationale stated for the location in the FSP Addendum (Table 1). If it does, the location is marked with fluorescent paint and metal pins with fluorescent nylon whiskers or wooden stakes at the precise GIS/GPS coordinates.

7. If the location is identified by the cultural, natural resource, or Native American monitor as a location of concern, they will demarcate restricted areas as necessary and determine the degree of support necessary for each sample location during the intrusive investigation (soil boring or excavation). Each proposed sample location is also preliminarily screened for radiation.

8. Once staked, the FTL will escort the subcontract utility locator (See Section 5.3) to clear all proposed sample locations for underground utilities. Samples locations affected by underground utilities will be noted, and an alternative location staked to avoid the utility. All adjusted sample locations will be reviewed with DOE, DTSC, and MWH; and the cultural and natural resource, and Native American monitors.

9. Proposed locations may be adjusted based on the following considerations:
   - sample locations that are impacted by overhead/underground utilities
   - sample locations that are impacted by steep or non-accessible terrain or exposed bedrock
   - sample locations that are impacted by archaeological/cultural resources
   - sample locations that are impacted by biological resources
   - sample locations that did not meet the intent of the MWH sample rationale

10. Using the final GPS coordinates, CDM Smith will provide the updated the sample location data to MWH for updating the Area IV GIS. Staff responsible for collecting GPS data for the sample locations will receive training specific on data collection and data file management including the following:
    - Transferring data files from and to GPS unit
    - Opening new files in GPS unit, collecting new points and properly closing data files
    - Checking data files in GPS unit and on computer after daily download
    - Field check of maps showing sample locations during sample event for consistency with sample identifiers, numbering, and locations.

    This training will be documented in a logbook. A revised sample location map will be incorporated into the FSP Addendum and provided to DOE and DTSC.

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11. DOE, DTSC, and MWH will have the opportunity to review all sample locations in the field and approve/accept the locations. Locations noted to be impacted or not meeting the intent of the sample collection rationale will be reviewed and direction will be provided to the FTL. Coordinates for adjusted samples locations will be immediately collected using the GPS unit and marked in the field as described above. Markers/paint of samples locations that will not be used will be destroyed at that time.

12. At each location, additional field-check of the sample location (coordinates) will be performed using the GPS unit at the time of sample collection.

5.2 GPS Survey

5.2.1 General

The following equipment is required to load and use GPS waypoint data for field surveys.

- ESRI ArcGIS Software
- Trimble Pathfinder Office Software
- TerraSync Software
- GeoExplorer 6000 Series Handheld Unit

The procedure to load and use GPS data consists of:

1. Load 2009 U.S. Department of Agriculture (USDA)National Agricultural Imagery Program (NAIP) color imagery onto GPS with the Pathfinder Office data transfer utility

2. Prepare GPS unit for data logging based on Chapter 9 (Setup Section) in “TerraSync Software Getting Started Guide”, which are as follows:

    a. 2.0 meter antenna height
    b. 30 positions logged and averaged for each collected sample location
    c. Required accuracy < 1.0 meter
    d. Quality of Global Navigation Satellite Systems (GNSS) positions logged will be controlled by the Trimble default “Smart Settings” referenced on page 181 of Chapter 9 of the Software Guide.

5.2.1 Method for Importing Sample Point Location Data

The following steps are used to load the data to the TerraSync software and should be done prior to navigating to a point (Chapters 5 and 6 of “TerraSync Software Getting Started Guide” can be referenced for further help):

1. Open TerraSync software on GPS unit and select ‘Data’ in the section list button
2. Tap ‘Manager – Existing File’
3. Select ‘MWH_SampleLoc.ssf’
4. Select ‘Map’ in the section list button
5. Tap ‘Layers – Background Files’
6. Check the box next to ‘SSFL_Aerial.sid’ and return to map view
7. Current location is denoted by a red x and the points on the map represent the MWH chosen sample locations.

The following steps must be taken to navigate to a given point (Chapter 7 of “TerraSync Software Getting Started Guide” can be referenced for further help):

1. Walk toward the nearest sample location with the FSP Addendum mapping and aerial photo as a reference
2. Select the point with the ‘select’ tool from the map tool dropdown list

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3. Tap 'Options – Set Nav Target'
4. Determine distance and bearing to target through the direction dial screen
5. A close-up screen will appear once target is within close proximity
6. Move toward the target and stop when the red x is within the center of the circle
7. Place the sample location pin or wooden stake at the base of the antenna

5.2.2 Coordinate Collection for Revised Sample Locations

The following steps will be taken to survey revised sample locations where the proposed location was deemed inaccessible due to underground utilities or the presence of archaeological/cultural, natural resource, or Native American considerations. CDM Smith will determine an alternate location for the sample and the coordinate data set will be updated using the GPS unit (Chapter 6 of "TerraSync Software Getting Started Guide" can be reference for further help):

1. Select 'Data' in the section list button
2. Select 'Update' from the sub-section list button
3. Tap 'Options – Logging Options' and confirm it is set to 'Update Feature (Replace)'
4. Return to the update features screen and select the sample location you intend to modify from the 'Choose Feature' list
5. Upload revised sample location files daily from hand-held GPS unit and send files to GIS specialists weekly for review.
6. FTL will field check maps of revised locations provided by GIS specialists for appropriate placement of sample locations.

5.2.3 Quality Assurance/Quality Control

Proper operation of the GPS unit will be demonstrated prior to and at the conclusion of each day's field activity. The following two permanent survey control points located within the SSFL Area IV will used to confirm the accuracy of the GPS unit:

Permanent Survey Control Point	Northing	Easting	Elevation
Set 2x2 w/ MG Tag #1	1907959.668000	6346660.571000	1825.270
Set 2x2 w/ MG Tag #2	1909915.202000	6350452.377000	1854.230
Set 1-in Pipe w/ MG Plastic Cap #3	1906485.748000	6344437.803000	1870.060
Set 1-in Pipe w/ MG Plastic Cap #4	1905107.447000	6344791.648000	2134.570
Set 1-in Pipe w/ MG Plastic Cap #5	1908215.335000	6348977.693000	1816.780

At the beginning and end of day, the GPS unit will be positioned directly over the Control Point and the coordinates recorded in the GPS unit. The GPS coordinates will be compared to the above stated survey control point coordinates. If comparison of the coordinates is within the acceptable required accuracy (< 1.0 meter) of the instrument, the GPS unit is locating properly and this information will be recorded in the logbook. If the coordinates are outside of the acceptable required accuracy (< 1.0 meter), then the SSFL SOP 16 should be consulted. Generally, if any field equipment fails to operate properly or provides inaccurate results, the field work will be temporarily suspended and the concern will be entered on the calibration log form and field logbook (SSFL SOP 8). Work will not resume until proper calibration is achieved or replacement equipment is received.

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5.3 Utility Location and Clearance

Prior to survey activities, all subcontractor equipment will be inspected by the FTL to ensure that the equipment meets Occupational Safety and Health Act (OSHA) or other contract or SSFL health and safety requirements. Following inspection, the utility locate survey will be conducted by the utility locator subcontractor:

1. Review GIS mapping of known utilities for utility types in vicinity of each proposed sampling location.

2. Using the geophysical instrumentation, search and mark on the ground the identified underground utilities, including, but not limited to, water lines, sewer lines, storm sewer lines, gas lines, electric lines, and telecommunication lines within a 10-foot radius of the sample location. Verify the proximity of any buried natural gas lines within 25-feet of the sampling point.

3. Search and mark, if identified, any anomalies representing potential subsurface structures or obstructions (such as, but not limited to, boulders, rebar, underground storage tanks, sinkholes, voids, buried artifacts, concrete pipes, etc.). Where possible, the concrete slab thickness shall also be estimated.

4. Additional soil boring/test pit utility clearing of all locations within a 10-foot radius of an identified utility or anomaly. Any identified utilities and anomalies shall be marked on the ground surface, on a hand-drawn sketch, and on a scaled site map. ***Note***: All test pit excavations require coordination and onsite oversight of the cultural, natural resource, and Native American monitors.

5. Provide field notes, hand-drawn sketches and scaled maps of each survey location to the FTL at the conclusion of each day. CDM Smith will make available to the subcontractor scaled base maps for the site.

All known surface and subsurface utilities located within the Area IV GIS will be used, in part, to determine the level of effort for clearing individual boring/test pit locations in (a) non-developed areas and (b) developed or previously developed areas or areas with known utilities. These areas and effort are discussed below.

5.3.1 Non-Developed Areas

The utility subcontractor will perform a reconnaissance survey of all areas that have no historic record of development and are absent of known utilities (as illustrated by the Area IV GIS). The subcontractor will physically inspect all or a portion of the area as necessary to provide assurance that the area does not contain utilities. The subcontractor will determine the identification method and effort necessary and communicate this information to the FTL prior to commencing of sampling activities in those areas. Following approval from the FTL or geologist, the utility subcontractor will clear soil boring/test pit locations. The utility subcontractor will mark utilities/features on the ground within the designated areas using a color code established by the American Public Works Association (and provided by the subcontractor).

5.3.2 Developed Areas and Areas with Know Utilities

In developed areas, the exteriors of the buildings, curbsides, streets, and/or land where building demolishing and dismantling activities have taken place, the utility subcontractor will visually inspect proposed sample/test pit locations for evidence of utilities. Exposed tracer wire or portions of metallic conduits and pipe will be used to conduct a signal with the instrument appropriate for a given type of utility. All utilities/features identified using conductive signals will be marked on the ground within the designated areas using a color code established by the American Public Works Association (and provided by the subcontractor).

The utility subcontractor will physically inspect all or a portion of the proposed sampling/test pit area as necessary to provide assurance that the area does not contain utilities and to identify any surface features (depressions, pits, trenches, etc.) or anomaly representing potential subsurface structures or obstructions (such as, but not limited to, boulders, rebar, underground storage tanks, voids, buried artifacts, concrete pipes, etc.).

For areas where soil borings are located within 10 feet, and test pits are within 50 feet, of an identified utility or identified subsurface features or anomaly, additional clearing of the soil boring/test pit location will be required. The utility subcontractor will provide additional clearing activities at these locations as described below.

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Equipment/instruments that do not use an induced current via pipe/conduit/wire will be swept over the ground surface within the designated clearance area. The signals will be traced at the surface and the underground utility or features will be delineated.

At a minimum, two 20-foot transects that are perpendicular to each other will be run within the diameter of each survey area. The transects will be centered on the boring/test pit location. Any surface features and anomaly representing potential subsurface structures or obstructions shall be identified and marked as appropriate. Where possible, the concrete slab thickness shall also be estimated.

5.4 Onsite Equipment and Vehicle Requirements

All equipment will be cleaned prior to entering and leaving SSFL. Vehicles are restricted to asphalt roads and parking lots and will be free of leaks. If vehicles or any equipment is leaking it will be taken out of service immediately and the fluids will be contained. Under CDM Smith's direction, the subcontractor will immediately clean up any petroleum or hydrocarbon fluid spills. Boeing, DOE, and DTSC will be immediately notified of any spills at the site.

6.0 Restrictions/Limitations

6.1 GPS Survey Instruments

External factors with the potential to degrade the quality of GPS data and the locating capabilities of the GPS are inherent within the GPS environment. A low signal to noise ratio (SNR), a high Position Dilution of Precision (PDOP), a multipath (GPS signal hits a physical barrier, thus reducing reflectivity), and a changing satellite constellation can all impact the quality of the GPS data. Because the equipment and logging settings are pre-determined for this project, inaccurate data due to the aforementioned external factors and potential human input errors should be minimized. The quality control procedures outlined in Section 5.2.3 will be followed to reduce GPS data quality issues/concerns.

7.0 References

National Geodetic Survey. 2012. "What We Do". http://www.ngs.noaa.gov/INFO/WhatWeDo.shtml

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Subsurface Soil Sampling With Hand Auger

SSFL SOP 3
Revision: 1
Date: December 2012

Prepared: J. Sobol **Technical Review:** C. Werden

QA Review: J. Oxford **Approved and Issued:** 12/13/2012
Signature/Date

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to define the techniques and requirements for collecting shallow subsurface soil samples for environmental characterization purposes from the unconsolidated subsurface. The sampling techniques discussed in this SOP involve use of hand augers at the Santa Susana Field Laboratory (SSFL) site.

2.0 Background

2.1 Definitions

Slide Hammer- A drive tool is used to drive and retract a 6-inch long and approximately 2-inches in diameter, thin-walled stainless steel sleeve.

Hand Auger - A stainless steel cylinder (bucket) approximately 3 to 4 inches (in) in diameter and 1 foot (ft) in length, open at both ends with the bottom edge designed to advance perpendicular to the ground surface with a twisting motion into unconsolidated subsurface material to obtain a soil sample. The auger has a T-shaped handle (fixed or ratchet used for manual operation) attached to the top of the bucket by extendable stainless steel rods.

EnCore® Sampler- A disposable plastic sampling device, typically with a capacity of 5 grams, used to obtain undisturbed, unconsolidated material samples (e.g., soil) for laboratory analyses. The sampler is inserted into a metal T-handle and the open end of the sampler pushed directly into the soil.

Subsurface Soil - The unconsolidated, or non-lithified, material that exists deeper than approximately 6 inches below the ground surface (bgs).

Unconsolidated Zone - A layer of non-lithified earth material (soil) that has no mineral cement or matrix binding its grains.

2.2 Associated Procedures

- SSFL SOP 1*, Procedures for Locating and Clearing Phase 3 Samples*
- SSFL SOP 6, *Field Measurement of Total Organic Vapors*
- SSFL SOP 7, *Field Measurement of Residual Radiation*
- SSFL SOP 8, *Field Data Collection Documents, Content, and Control*
- SFSL SOP 9, *Lithologic Logging*
- SSFL SOP 10, *Sample Custody*
- SSFL SOP 11, *Packaging and Shipping Environmental Samples*
- SSFL SOP 12, *Field Equipment Decontamination*
- SSFL SOP 13, *Guide to Handling Investigation Derived Waste*
- SSFL SOP 15, *Photographic Documentation of Field Activities*
- SSFL SOP 16, *Control of Measurement and Test Equipment*

2.3 Discussion

Subsurface soil samples, or those taken from depths below 6 inches, are collected using a hand auger to depths up to 10 ft bgs or bedrock refusal. Subsurface samples in locations inaccessible to a DPT rig will be collected by drilling using hand augers to the sample depth, and then sample collection from the auger hole using a slide hammer and stainless steel sleeves. The maximum depth of hand auger samples is typically 10 feet bgs. All sample locations and sample materials will be screened by the Site Health and Safety Technician using hand-help instruments. In addition, all SOPs will be on hand

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with the field sampling team.

3.0 General Responsibilities

Field Team Leader - The field team leader is responsible for ensuring that field personnel collect subsurface soil samples in accordance with the Field Sampling Plan (FSP) Addendum and this SOP.

Site Geologist – The person responsible for collecting and logging the soil sample.

Site Health and Safety Technician– The person who will use field screening instruments to monitor all field activities for VOCs and radiological contaminants and pre-shipment sample coolers. This person is a trained radiological technician who works under the guidance of Science Application International Corporation's (SAIC's) Certified Health Physicist (CHP).

4.0 Required Equipment at the Sampling Location

4.1 General

- Site-specific plans (e.g., FSP Addendum, health and safety) including all SOPs
- Field logbook
- Appropriate sample containers
- EnCore samplers and T-handle
- Insulated cooler(s)
- Bags of ice
- Nitrile or appropriate gloves
- 2-way radios
- Indelible black ink pens and markers
- Slide hammer with stainless steel sleeves
- Global Positioning System (GPS) unit
- Monitoring/screening equipment per health and safety plan
- Personal protective clothing and equipment
- Plastic sheeting
- Plastic zip-top bags
- Trash bags
- Disposable plastic spoons or knives
- Sample labels
- Decontamination supplies
- Kimwipes or paper towels
- Teflon squares and sleeve end caps

4.2 Manual (Hand) Auger Sampling

- T-handle
- Hand auger: extensions, bucket-, or tube-type auger as required by the site-specific plans
- Extension rods
- Wrench(es), pliers

5.0 Procedures

5.1 Preparation

1. Review site-specific health and safety plan and FSP Addendum before initiating sampling activity.

2. Don the appropriate personal protective clothing as indicated in the site-specific health and safety plan.

3. Locate sampling location(s) in accordance with FSP Addendum and document pertinent information in the appropriate field logbook (SSFL SOP 8). Confirm GPS coordinates of each location (SSFL SOP 1).

4. Use clean, (decontaminated) sampling tools per SSFL SOP 12 used to obtain sample material from each specified sample location.

5. Carefully remove stones, vegetation, debris, etc. from the ground surface in the sampling location area. Clear the sample location using a new and/or appropriately decontaminated tool as described to expose a fresh sampling surface.

6. The Site Health and Safety Technician will perform contaminant screening using hand-held instruments at each sample location before sampling and for each sample collected (SSFL SOPs 6 and 7*).* The most recent spoils materials will be segregated to minimize cross-contamination. The breathing zone and excavated materials will be monitored continuously. If levels are detected above health and safety plan action levels (HASP page 8), work will be temporarily discontinued. If radiation levels exceed two-times (2X) background levels (HASP page 8), the Department of Energy

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(DOE),The Boeing Company (Boeing), and the California Department of Toxic Substances Control (DTSC) will be contacted. Site work will not resume at that location until further guidance is provided by DOE or Boeing. Contact information is in the health and safety plan.

The following steps must be taken to prepare the slide hammer for sampling.

1. Obtain the slide hammer, sample tube with the shoe and stainless steel liners.
2. Remove the sample tube shoe and insert a clean liner. Screw the shoe back onto the sample tube.
3. Screw the assembled sample tube onto the slide hammer.
4. After sampling remove the sampling liner from the sample tube for sample collection.
5. Decontaminate the sample tube and shoe.

5.2 Sample Collection

The following general steps must be followed when collecting all subsurface soil samples. Soil samples will be preserved by placing the samples on ice.

1. Wear clean gloves during handling of sample containers and sampling devices. Change out gloves at each sampling location, or each time a new sample is to be collected, to avoid cross-contamination.
2. VOC samples or samples that may be degraded by aeration will be collected first and with the least disturbance possible to minimize sample disturbance and consequently minimize analyte loss.
3. While advancing the hand auger, the subsurface lithology shall be described according to SSFL SOP 9.
4. Specific sampling devices are identified in the FSP Addendum and will be recorded in the field logbook. Document any and all deviations from the SOPs and the sampling plan in the field logbook and include rationale for changes. See SSFL SOP 8 for guidance on entering information into field log books.
5. Care must be taken to prevent cross-contamination and misidentification of samples as described in subsequent subsections of this SOP.

5.2.1 Manual (Hand) Auger Sampling Using a Slide Hammer

The following steps must be followed when collecting environmental soil samples using a hand-auger and slide hammer:

1. Auger to the depth required for sampling, per the FSP Addendum. Place cuttings on plastic sheeting. If possible, lay out the cuttings in stratigraphic order.
2. During auger advancement and sample collection, record observations made of the geologic features of the soil or sediments per SSFL SOP 9.
3. Stop advancing the auger when the top of the specified sampling depth has been reached. Remove the auger from the hole and set aside for future decontamination (see line item 11 below).
4. Obtain the subsurface soil sample by driving the sample sleeve through the specified sample interval with the slide hammer. Remove the stainless steel liner from the slide hammer and quickly screen the sleeve for VOCs and radiation (SSFL SOPs 6 and 7).
5. Immediately subsample for VOCs (if required) by FSP Addendum Table 1, observe stained soil, petroleum odor, or elevated PID reading) by pushing the EnCore sampler into the soil in the bottom end of the sampling sleeve. See

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Section 5.2.2.

6. Decontaminate the auger bucket, sample tube and shoe, and repeat the preceding steps for sample collection from deeper depths as required by the FSP Addendum.

7. When sampling is complete, place cuttings back into the borehole, and top off with bentonite pellets, and hydrate as necessary to bring former borehole to ground surface. Place plastic sheeting and gloves in garbage bag and transfer decontamination water to storage container as specified SSFL SOP 13.

8. Decontaminate all equipment between each sample according to SSFL SOP 12.

9. Complete the field logbook entry and other forms, being sure to record all relevant information before leaving the sample location.

5.2.2 Method for Collecting Soil Samples for Volatile Organic Compound Analysis

The following text contains the recommended SW-846 Test Method 5035 procedure for sampling and field preservation of soil samples for volatile organic compound (VOC analyses, which includes the EnCore® Sampler Method for low-level VOC analyses.

1. When collecting grab sampling for VOC analysis, it is necessary to minimize sample disturbance and consequently minimize analyte loss.

2. Wear new, clean gloves during handling of sample containers and sampling devices. Change out gloves at each sampling location, or each time a new sample is to be collected, to avoid cross-contamination.

3. VOC samples shall be collected first as grab samples. EnCore samplers will be used to collect subsamples for the required analytical protocol (e.g., VOCs1,4-dioxane and total petroleum hydrocarbon-gasoline range organics [TPH-GRO) from sample sleeves collected at depth. The VOC samples will be collected from the bottom of the 6-inch stainless steel sleeve. Several slide hammer samples (stainless steel liners) may be required to obtain the required sample volume for all VOC analyses.

4. Once the sleeve is retrieved, quickly screen the open end of the sleeve and the sample borehole for VOCs and radioactivity (SSFL SOPs 6 and 7).

5. Remove EnCore sampler and cap from package and attach T-handle to sampler body. Ensure that the sampler is locked into the T-handle before sampling.

6. Push the sampler into the freshly-exposed soil in the bottom of the sampler sleeve until the O-ring is visible within the hole on the side of the T-handle. If the O-ring is not visible within this window, then the sampler is not full.

7. Extract the sampler and wipe the sampler sides with a clean paper towel or Kimwipe so that the sampler cap can be tightly attached.

8. While still locked into the T-handle, push the sampler cap on the head of the sampler with a twisting motion to secure it to the sampler body.

9. Remove the sampler from the T-handle and rotate the sampler stem counterclockwise until the stem locks in place to retain the sample within the sampler body.

10. Repeat procedures for each of the remaining Encore Samplers.

11. When collecting soil samples using the EnCore Sampler Method, collection of soil for moisture content analysis is required. Results of the moisture analysis are used to adjust “wet” concentration results to “dry” concentrations to meet analytical

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method requirements. The moisture sample will be collected in a separate 4 oz. glass jar. If only VOCs/1,4-dioxane are to be sampled at a location, after collecting the required number of EnCore samples, fill one 4 oz. jar with soil from bottom of stainless steel sleeve for moisture analysis using a disposable plastic spoon or knife.

12. Remaining material in the sleeve may be used for any required non-volatile analyses (Section 5.2.3)

13. Complete the sample labels by filling in the appropriate information (i.e., sample identification, date and time of sample collection, and requested analyses per FSP Addendum Table 1 and securing the label to the container.

14. Store samples at 4°C (±2°C) until samples are delivered to the FTL or sample coordinator (per SOP 10) for sample packing and shipment (per SOP 11) to the designated analytical laboratory. EnCore samplers must be shipped and delivered to the analytical laboratory for extraction within 48 hours.

15. Decontaminate all non-disposable sampling equipment in accordance with SSFL SOP 12.

Note: A water trip blank will be included with sample coolers containing VOC samples.

5.2.3 Method for Collecting Samples for Nonvolatile Organic or Inorganic Compound Analyses

The requirements for collecting samples of subsurface soil for nonvolatile organic or inorganic analyses are as follows:

1. Use a clean slide hammer and decontaminated stainless steel sleeves to drive a sample through a 6-inch interval at the prescribed depth. Several sleeves may be required from this interval to collect the necessary amount of subsurface soil to satisfy the analytical protocol (refer to sampling rationale Table 1 in the FSP Addendum). Quickly screen the open end of the sleeve and the sample borehole for VOCs and radioactivity (SSFL SOPs 6 and 7).

2. Collect sub samples for hexavalent chrome (Cr^{6+}) and or pHfrom the center of the stainless steel sleeve into a glass jar using a disposable plastic spoon or knife. Ensure that the soil that was in contact with the sleeve is not collected in the jar.

3. Prior to capping the sleeve for the remaining non-volatile parameters, place a Teflon® cover sheet over each end of the sample. Secure the respective cap on each sample container immediately after collection.
4.
5. Label the sample sleeve with “top” and “bottom” designations.

6. Wipe the sample containers with a clean paper towel or Kimwipe to remove any residual soil from the sample container surface.

7. Fill out the sample label with the appropriate sample information (e.g., sample identification, date/time of sample collection, requested analyses per FSP Addendum Table 1 and attach to sample sleeve.

8. Place sample containers in individual zip-top plastic bags and seal the bags. Place baggies onto ice in an insulated cooler to maintain at 4°C (±2°C) until samples are delivered to the FTL or sample coordinator (per SOP 10) for sample packing and shipment (per SOP 11) to the designated analytical laboratory.

9. Decontaminate all non-disposable sampling equipment in accordance with SSFL SOP 12.

6.0 Restrictions/Limitations

Before conducting the soil sampling at each location, underground utilities and structures must be demarcated on the ground surface. In addition, archeological and cultural resources as well as Native American cultural concerns must be cleared. A subcontractor will be used to locate and mark the utility lines. The selected sampling location shall be a safe distance from the demarcated utility. In some cases, records regarding utility locations may not exist.

Also, when grab sampling for VOC analysis or for analysis of any other compound(s) that may be degraded by aeration, it is necessary to minimize sample disturbance and analyte loss. The representativeness of a VOC grab sample is difficult to

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determine because the collected sample represents a single point, is not homogenized, and has been disturbed.

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American Society for Testing and Materials. 1999. *Standard Test Method for Penetration Test and Split Barrel Sampling of Soils*. Standard Method D1586-99.

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_____. Hazardous Waste Remedial Actions Program. *Standard Operating Procedures for Site Characterizations*, DOE/HWP-100/R1. September 1996 or current revision.

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Direct Push Technology (DPT) Sampling

SSFL SOP 4
Revision: 1
Date: November 2012

Prepared: P. Hartman **Technical Review:** C. Werden

QA Review: C. Sayler **Approved and Issued:** 11/20/2012
Signature/Date

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to define the requirements for collecting subsurface soil using direct push technology (DPT) sampling techniques at the Santa Susana Field Laboratory (SSFL) site.

2.0 Background

2.1 Definitions

DPT rig- A hydraulically-operated hammer device installed on the back of a van, pickup truck, or skid used to advance a hollow-stem rod and sampler into the subsurface soil (up to bedrock refusal) to collect subsurface soil samples.

Probe-Driven Sampler - A sampling device used to collect soil samples with a DPT rig. The sampler is 5-foot steel core barrel with an acetate liner to contain the sample.

Extension Rod - Stainless steel rod used to remove stop-pin and drive-point assembly.

Drive Point - Solid steel retractable point used to advance sample collection device to the required sample depth.

Probe Rod - Hollow, flush-threaded, steel rod similar to a drill rod.

Stop-Pin - Steel plug that threads into the top of the drive cap to hold the drive point in place during advancement of the probe rods.

Drive Cap - Threaded, hardened-steel top cap that attaches to the top of the probe rod; used when advancing the probe rods with the hydraulic hammer.

Pull Cap - Threaded, hardened-steel top cap that attaches to the top of the probe rod; used when retracting the probe rods.

2.2 Associated Procedures

- SSFL SOP 1, *Procedures for Locating and Clearing Phase 3 Samples*
- SSFL SOP 6, *Field Measurement of Total Organic Vapors*
- SSFL SOP 7, *Field Measurement of Residual Radiation*
- SSFL SOP 8, *Field Data Collection Documents, Content, and Control*
- SSFL SOP 9, *Lithologic Logging*
- SSFL SOP 10, *Sample Custody*
- SSFL SOP 11, *Packaging and Shipping Environmental Samples*
- SSFL SOP 12, *Field Equipment Decontamination*
- SSFL SOP 13, *Guide to Handling Investigation Derived Waste*
- SSFL SOP 15, *Photographic Documentation of Field Activities*
- SSFL SOP 16, *Control of Measurement and Test Equipment*

2.3 Discussion

The DPT rig consists of a hydraulically-operated hammer device mounted on the back of a van, a pickup truck or a skid. The DPT system hydraulically advances small-diameter hollow rods and sampler to the desired sampling depth. The specific type of DPT sampling equipment for soil sample collection is then deployed. This work will be performed by a subcontractor with CDM Smith oversight.

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Direct Push Technology (DPT) Sampling

SSFL SOP 4
Revision: 1
Date: November 2012

The use of DPT technology is a cost-effective alternative to using conventional drilling techniques for collecting subsurface soil samples given the site-specific geologic and hydrogeologic conditions and sample requirements.

Advantages of using the DPT system include:

- Areas usually considered inaccessible by drill rigs because of terrain and vegetation, overhead wires, size constraints, etc., may be accessed with a van or pickup truck-mounted DPT rig.
- Investigation-derived wastes such as soil cuttings and purge water are minimized due to its small diameter rods and its displacement of soil horizontally, not vertically.
- Areas where traditional surface sampling equipment (e.g., Slide Hammer or Hand Auger) cannot penetrate the hard surface, a DPT rig may be used to obtain the sample(s).

In addition, all SOPs will be on hand with the field sampling team.

3.0 General Responsibilities

DPT Subcontractor–Subcontractor retained to perform all DPT drilling activities.

Field Team Leader (FTL)-The FTL is responsible for ensuring that sampling efforts are conducted in accordance with this procedure and the Field Sampling Plan (FSP) Addendum and this SOP.

Site Health and Safety Technician–The person who will use field screening instruments to monitor all field activities for VOCs and radiological contaminants and pre-shipment sample coolers. This person is a trained radiological technician who works under the guidance of Science Application International Corporation's (SAIC's) Certified Health Physicist (CHP).

Site Geologist–The person responsible for overseeing sample collecting, recording sampling information and for logging the soil sample.

4.0 Required Equipment at the Sampling Location

General

- Site-specific plans (e.g., FSP Addendum, health and safety plan, and all SSFL SOPs)
- Field logbook
- Appropriate sample containers
- Insulated coolers
- Bags of ice
- Indelible black or blue ink pens and markers
- Plastic zip-top bags
- Nitrile or appropriate gloves
- Personal protective equipment
- Global Positioning System (GPS)
- 2-way radios
- Monitoring/screening instruments required by the health and safety plan
- Plastic sheeting
- Decontamination supplies
- Trash bags
- Sample labels
- Kimwipes or paper towels
- Stainless steel trowel
- EnCore samplers and T-handle
- Plastic spoons or knives

DPT Soil Sampling Equipment

- DPT rig (tracked vehicle, van or truck-mounted) with the following:
  - Probe rods 5-foot [ft]) lengths
  - Extension rods (5-ft) lengths, couplers, and handle
  - Piston stop-pins (two each per rig, minimum)
  - Drive caps and pull caps (two each per rig, minimum)
  - Carbide-tipped drill bit for working in concrete- or asphalt-covered areas

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- O-rings
- Assembled soil samplers (5-foot long continuous split-barrel with acetate sleeve)

5.0 Procedures

Subsurface and surface soil sampling procedures are discussed below. CDM Smith will oversee DPT operations and handle the samples. It is the DPT subcontractor's responsibility to operate the DPT equipment.

1. Review site-specific health and safety plan and FSP Addendum before initiating sampling activity.

2. Don the appropriate personal protective clothing as indicated in the site-specific health and safety plan.

3. Locate sampling location(s) in accordance with FSP Addendum and document pertinent information in the appropriate field logbook (SSFL SOP 8). Confirm GPS coordinates of each location (SSFL SOP 1).

4. Use clean (decontaminated) sampling tools to obtain sample material from each specified sample location.

5. Carefully remove stones, vegetation, debris, etc. from the ground surface in the sampling location area. Clear the sample location using a new and/or appropriately decontaminated tool as described to expose a fresh sampling surface.

6. The Site Health and Safety Technician will perform contaminant screening using hand-held instruments at each sample location before sampling and for each sample collected (SSFL SOPs 6 and 7*)*. The most recent spoils materials will be segregated to minimize cross-contamination. The breathing zone and excavated materials will be monitored continuously. If levels are detected above health and safety plan action levels (HASP page 8), work will be temporarily discontinued, the Department of Energy (DOE), The Boeing Company (Boeing), and the California Department of Toxic Substances Control (DTSC) will be contacted. Site work will not resume at that location until further guidance is provided by DOE or Boeing. Contact information is in the health and safety plan.

7. If the sampling site is in an asphalt-covered area, drill a hole using the rotary function and a specially designed (1.5-inch or 2.0-inch diameter) carbide-tipped drill bit. Otherwise, the area needs to be cleared of heavy underbrush and immediate overhead obstructions.

5.1 Subsurface Soil Sampling

Assembly

1. Assemble the sampling device as follows:
   - Screw the cutting shoe to the bottom end of the sample tube, unless using standard probe drive sampler which has a built-in cutting edge.
   - Screw the piston tip onto the piston rod.
   - Screw the drive head onto the top end of the sample tube.
   - Insert the acetate liner into sample tube.
   - Slide the piston rod into the sample tube, leaving the piston tip sticking out of the bottom end of the sample tube.
   - Screw the piston stop-pin onto the top end of the piston rod in a counter-clockwise direction.

2. Attach the assembled sampler onto the leading probe rod.

Probing

3. Thread the drive cap onto the top of the probe rod and advance the sampler.

4. Advance the sampler using the hydraulic hammer. Add additional probe rods as necessary to reach the specified sampling depth (see Table 1 in FSP Addendum).

Stop-Pin Removal

5. Move the probe unit back from the top of the probe rods and remove the drive cap.

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6. Lower the extension rods into the inside diameter of the probe rods using extension rod couplers to join the extension rods.

7. Attach the extension rod handle to the top extension rod and rotate the handle clockwise until the leading extension rod is screwed into the piston stop-pin. Continue to rotate the handle clockwise until the stop-pin disengages from the drive head.

8. Remove the extension rods and attached piston stop-pin from the probe rods.

Continuous Sampling
Direct push sampling will be performed with a dual–tube sampling method using a specialty continuous coring sampler (4-ft with inner acetate sleeve). The sampler is driven in 4-ft intervals slightly ahead of stainless steel casing, and retrieved after each interval push as described above.

9. Replace the drive cap.

10. Advance the probe rods using the hydraulic hammer the length of the sample tube (4 ft).

11. Replace the drive cap with the pull cap and retract the probe rod(s). Secure the rod(s) with a clamp or by hand during removal so they do not fall back down the resulting borehole.

12. Detach the sampler from the lead probe rod, verifying that sufficient sample volume was recovered (Note: The length of sample contained within the tube is approximately equal to the length of exposed piston rod).

13. Disassemble the sampler. Remove the acetate liner. Use cutting tool to cut length of liner (2 times) to remove an approximate 1-inch strip to access the sample material.

14. The Site Health and Safety Technician will perform contaminant screening along the length of the acetate liner using hand-held instruments (SSFL SOPs 6 and 7*).* The most recent spoils materials will be segregated to minimize cross-contamination. The breathing zone and excavated materials will be monitored continuously. If levels are detected above health and safety plan action levels (HASP page 8), work will be temporarily discontinued and DOE, Boeing, and DTSC will be contacted. Site work will not resume at that location until further guidance is provided by DOE or Boeing. Contact information is in the health and safety plan.

15. If the PID indicates elevated VOCs or there is staining or discoloration evident, immediately collect VOC/1,4-dioxane and total petroleum hydrocarbons-gasoline range organics (TPH-GRO) samples using EnCore samplers per Section 5.2.

16. If there is no indication of contamination, collect the required number of Encore samplers for TPH-GRO analysis (if required by Table 1 of the FSP Addendum), then collect soil from the target interval as stated in the FSP Addendum Table 1, and place into glass jars using disposable plastic spoons or knives.

17. Wipe sealed jars with a clean Kimwipe or paper towel.

18. Fill out the sample label with the appropriate sample information (e.g., sample identification, date/time of sample collection, requested analyses per Table 1 of FSP Addendum) and attach to sample container.

19. Place sample containers in zip-top plastic bags and seal the bags. Place samples in a cooler with ice to maintain a temperature of 4°C ($\pm$2°C).

20. Proceed with additional sample depth collection as required by the FSP Addendum.

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21. When sampling is complete, place cuttings back into the borehole and top off with bentonite pellets, as necessary, to bring former borehole to ground surface. Place plastic sheeting and gloves in garbage bag and transfer decontamination water to storage container as specified in SSFL SOP 13.

22. Decontaminate the sampling equipment according to SSFL SOP 12.

23. Complete the field logbook entry (SSFL SOP 8), field sample data sheet for each sample, and lithologic log (SSFL SOP 9), being sure to record all relevant information before leaving the sample location.

24. Demobilize from sample location.

5.2 Method for Collecting Soil Samples for Volatile Organic Compound Analysis

The following text contains the recommended SW-846 Test Method 5035 procedure for sampling of soil samples for volatile organic compound (VOC) analysis, which includes the EnCore™ Sampler Method for low-level VOC analyses.

1. When collecting grab samples for VOC analysis, it is necessary to minimize sample disturbance and minimize analyte loss.

2. Wear new, clean gloves while handling sample containers and sampling devices. Change out gloves at each sampling location, or each time a new sample is to be collected to avoid cross-contamination.

3. The VOC samples shall be collected first as grab samples. EnCore samplers will be used to collect subsamples for the required analytical protocol (e.g., VOCs/1,4-dioxane and/or TPH-GRO). The VOC samples will be collected directly from the appropriate interval within the acetate sleeve – in a section of staining, odor, and/or PID response, or at the target depth per the FSP Addendum Table 1. Additional DPT cores may be necessary for all analyses.

4. Once the sleeve is retrieved, quickly screen the open end of the sleeve and the sample borehole for VOCs and radioactivity (SSFL SOPs 6 and 7).

5. Remove EnCore sampler and cap from package and attach T-handle to sampler body. Ensure the sampler is locked into the T-handle before sampling.

6. Push the sampler into the freshly-exposed sample in the acetate liner until the O-ring is visible within the hole on the side of the T-handle. If the O-ring is not visible within this window, then the sampler is not full.

7. Extract the sampler and wipe the sampler sides with a clean paper towel or Kimwipe so that the sampler cap can be tightly attached.

8. While locked into the T-handle, push the sampler cap on the head of the sampler with a twisting motion to secure it to the sampler body.

9. Remove the sampler from the T-handle and rotate the sampler stem counterclockwise until the stem locks in place to retain the sample within the sampler body.

10. **Repeat** procedure for each of the remaining samplers.

11. When collecting soil samples using the EnCore Sampler Method, collection of soil for moisture content analysis is required. Results of the moisture analysis are used to adjust “wet” concentration results to “dry” concentrations to meet analytical method requirements. The moisture sample will be collected in a separate 4 ounce (oz.) glass jar. If only VOCs/1,4-dioxane are to be sampled at a location, following EnCore sample collection, fill one 4 oz. jar with soil from the liner in close proximity to the VOC samples for moisture analysis using a disposable plastic spoon or knife.

12. Complete the sample labels by filling in the appropriate information (i.e., sample identification, date and time of sample

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collection, requested analyses [per Table 1 of FSP Addendum]) and securing the label to the container.

13. Store samples at 4°C (±2°C) until samples are delivered to the FTL or sample coordinator (per SSFL SOP 10) for sample packing and shipment (per SSFL SOP 11) to the designated analytical laboratory. Encore samplers must be shipped and delivered to the analytical laboratory for extraction within 48 hours.

14. Decontaminate all non-disposable sampling equipment in accordance with SSFL SOP 12.

Note: A water trip blank will be included with sample coolers containing VOC samples.

5.3 Method for Collecting Samples for Nonvolatile Organic or Inorganic Compound Analyses

The requirements for collecting samples of subsurface soil for nonvolatile organic or inorganic analyses are as follows:

1. Wear new, clean gloves while handling sample containers and sampling devices. Change out gloves at each sampling location, or each time a new sample is to be collected to avoid cross-contamination.

2. The non-VOC samples will be collected after VOCs; a separate sampler with acetate liner will likely be needed. Collect the sample from a 6-inch section from the appropriate interval within the acetate sleeve – in a section of staining, odor, or PID response, or at the target depth per the FSP Addendum. Before sampling, quickly screen the length of the acetate liner for VOCs and radioactivity (SSFL SOPs 6 and 7).

3. Using a decontaminated stainless steel or plastic spoon or trowel, scoop soil from the acetate liner (from the 6-inch target interval) into the required glass sample jars.

4. Wipe the sample containers with a clean paper towel or Kimwipe to remove any residual soil from the sample container surface.

5. Fill out the sample label with the appropriate sample information (e.g., sample identification, date/time of sample collection, requested analyses per FSP Addendum Table 1, and attach to sample jar(s).

6. Place sample containers in individual zip-top plastic bags and seal the bags. Place baggies onto ice in an insulated cooler to maintain at 4°C (±2°C) until samples are delivered to the FTL or sample coordinator (per SSFL SOP10) for sample packing and shipment (per SSFL SOP 11) to the designated analytical laboratory.

7. Decontaminate all non-disposable sampling equipment in accordance with SSFL SOP 12.

5.4 Method for Surface Soil Collection by Direct Push Technology

Collection of surface soil samples with the Direct Push Technology (DPT) is allowed when hard soil conditions prevent collection via slide hammer. The following text contains the recommended procedure for sampling

Follow steps 1 thru 7 under SOP 4 paragraph 5.0 (Procedures) prior to sampling.

Assembly

1. Assemble the sampling device (sampler) as follows:
   - Screw the cutting shoe to the bottom end of the sampler, unless using standard probe drive sampler which has a built-in cutting edge.
   - Screw the piston tip onto the piston rod.
   - Screw the drive head onto the top end of the sampler.
   - Insert a stainless steel sleeve (5 ¾ inches x 1 ¾ inches each) into the sampler.
   - Slide the piston rod into the sample tube, leaving the piston tip sticking out of the bottom end of the sampler.
   - Screw the piston stop-pin onto the top end of the piston rod in a counter-clockwise direction.

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Probing

3. Thread the drive cap onto the top of the probe rod and advance the sampler.

4. Advance the sampler using the hydraulic hammer 6-inches into the surface to collect the sample and retrieve the sampler (step 5).

Stop-Pin Removal

5. Move the probe unit back from the top of the probe rods and remove the drive cap.

6. Lower the extension rods into the inside diameter of the probe rods using extension rod couplers to join the extension rods.

7. Attach the extension rod handle to the top extension rod and rotate the handle clockwise until the leading extension rod is screwed into the piston stop-pin. Continue to rotate the handle clockwise until the stop-pin disengages from the drive head.

8. Remove the extension rods and attached piston stop-pin from the probe rods.

9. Disassemble the sampler. Remove the stainless steel sleeve representing the surface sample.

10. The Site Health and Safety Technician will perform contaminant screening at the top and bottom of the stainless steel sleeve using hand-held instruments (SSFL SOPs 6 and 7*).* The breathing zone and extracted materials will be monitored continuously. If levels are detected above health and safety plan action levels (HASP page 8), work will be temporarily discontinued, the DOE, Boeing, and DTSC will be contacted. Site work will not resume at that location until further guidance is provided by DOE or Boeing. Contact information is in the health and safety plan.

11. If the PID indicates elevated VOCs or there is staining or discoloration evident, immediately collect VOC/1,4-dioxane and total petroleum hydrocarbons-gasoline range organics (TPH-GRO) samples from the bottom of the stainless steel sleeve using EnCore samplers per SOP 2, Section 5.2.2

12. If there is no indication of contamination, collect the required number of Encore samplers for TPH-GRO analysis (if required by Table 1 of the FSP Addendum), immediately cap both ends of the stainless steel ring with Teflon and caps. Label the top and bottom of the sample.

13. Wipe the capped sleeve with a clean Kimwipe or paper towel.

14. Fill out the sample label with the appropriate sample information (e.g., sample identification, date/time of sample collection, requested analyses per Table 1 of FSP Addendum) and attach to sample container.

15. Place sample containers in zip-top plastic bags and seal the bags. Place samples in a cooler with ice to maintain a temperature of 4°C ($\pm$2°C). Store samples at 4°C ($\pm$2°C) until samples are delivered to the FTL or sample coordinator (per SSFL SOP 10) for sample packing and shipment (per SSFL SOP 11) to the designated analytical laboratory

16. Repeat surface sampling process with steps 1 through 4 if additional volume is needed at the location to address the analytical requirement per Table 1 of the FSP Addendum. Move the sample tool entry point 6 inches away from initial sample point and collect the next sample. Repeat steps 5 through 15 to retrieve and process the sample.

Proceed with additional subsurface sample depth collection per Paragraph 5.1 above as required by the FSP Addendum.

17. When sampling is complete, place cuttings back into the borehole and top off with bentonite pellets, as necessary, to bring former borehole to ground surface. Place plastic sheeting and gloves in garbage bag and transfer decontamination water to storage container as specified in SSFL SOP 13.

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18. Decontaminate the sampling equipment according to SSFL SOP 12.

19. Complete the field logbook entry (SSFL SOP 8), field sample data sheet for each sample, and lithologic log (SSFL SOP 9), being sure to record all relevant information before leaving the sample location.

20. Demobilize from sample location.

6.0 Restrictions/Limitations

Before conducting the DPT sampling event, underground utilities and structures must be demarcated on the ground surface. In addition, archeological and cultural resources as well as Native American cultural concerns must be cleared. A subcontractor will be used to locate and mark the utility lines. The selected sampling location shall be a safe distance from the demarcated utility. In some cases, records regarding utility locations may not exist. In any event, a good practice is to slowly push the probe rods the first few feet (rather than hammering) to ensure that no utilities, underground storage tanks, or other subsurface structures are present.

Also, when grab sampling for VOC analysis or for analysis of any other compound(s) that may be degraded by aeration, it is necessary to minimize sample disturbance and analyte loss. The representativeness of a VOC grab sample is difficult to determine because the collected sample represents a single point, is not homogenized, and has been disturbed.

7.0 References

Geoprobe® Systems. 1991. *The Probe-Drive Soil Sampling System.* September.

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Field Measurement of Total Organic Vapors

SSFL SOP 6
Revision: 1
Date: June 2012

Prepared: J. Sobol **Technical Review:** C. Werden

QA Review: J. Oxford **Approved and Issued:** 6/12/2012
Signature/Date

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to define the techniques and the requirements for the measurement of total organic vapors in the breathing zone and in field samples at the Santa Susana Field Laboratory (SSFL) site.

2.0 Background

2.1 Definitions

Photoionization detector (PID) – A portable, hand-held instrument that measures the concentration of gaseous organic compounds through the photoionization of organic vapors.

2.2 Associated Procedures

- SSFL SOP 1, *Procedures for Locating and Clearing Phase 3 Samples*
- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology (DPT) Sampling*
- SSFL SOP 5, *Backhoe Trenching/Test Pits for Sample Collection*
- SSFL SOP 9, *Lithologic Logging*

2.3 Discussion

The measurement of organic vapors is a required step during numerous field activities. The measurement of organic vapors is being performed for two purposes. The first objective is to address health and safety concerns to determine if the breathing zone in a work area is acceptable or if personal protective equipment such as a respirator or a supplied air device is necessary for field personnel. The second objective is to assist in the identification of contamination and possible sample intervals for field judgment decisions on where samples for volatile organic compounds (VOCs) should be collected.

Samples to be screened include excavation spoils, hand auger cuttings, sample material from an acetate liner or stainless steel sleeve, as well as in situ screening. All sample material will be screened for the presence of volatile organic chemicals.

2.3.1 PID Operation

The PID is preferred when the compounds of interest are aromatics or halogenated VOCs. The PID ionizes the sampled vapors using an ultraviolet lamp that emits light energy at a specific electron voltage (eV - labeled on the lamp). Every organic compound has a specific ionization potential (measured in electron volts). The energy emitted by the lamp must be higher than the ionization potential of the compound for the compound to become ionized and emit an electron. If the ionization potential of the compound is higher than the eV of the lamp, there will be no response on the instrument. Therefore, the ionization potential of the known or suspected compounds shall be checked against the energy of the ultraviolet lamp (i.e., typically 10.2 eV, 10.7 eV, or 11.7 eV) to verify that the energy provided by the lamp is greater. Consult the manufacturer's manual to determine the appropriate ultraviolent lamp to be used and obtain the appropriate correction factors for known or suspected contaminants.

Water vapor associated with samples can interfere with the PID detector and cause the instrument to stop responding. This can be caused by using the PID on a rainy day or when sampling headspace samples that have been in the sun. If moisture is suspected, use the calibration gas to check the instrument response by inserting the gas as a check sample,

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not by recalibrating. If the response is lower than the gas level, then dry out the probe and the ionization chamber before reusing the instrument.

Do not insert the sampling probe directly into soil samples or dusty areas, as the instrument vacuum will pull dirt into the ionization chamber. Under particularly dirty or dusty conditions, the lamp may become covered with a layer of dust. If dirty conditions are encountered, or if the instrument response seems to have decreased, then clean the lamp. The instrument comes with an inlet filter that can be used to control dust and moisture. The instrument manual provides instructions on removing the instrument cover to access the lamp, and cleaning the screen in the ionization chamber as well as the surface of the lamp. In addition, the ultraviolet lamp in the PID is sensitive to shock, especially when using the higher eV lamps. Therefore, handle and transport the equipment carefully.

Finally, make sure the battery is fully charged before use. The average battery life is on the order of 8 to 12 hours of continuous use. Also, make sure the unit is allowed to equilibrate to ambient outdoor temperatures.

3.0 Responsibilities

Field Team Leader– The field team leader (FTL) is responsible for ensuring that field personnel conduct field activities in accordance with this SOP and the Field Sampling Plan (FSP) Addendum.

Site Geologist – The person responsible for overseeing soil sample collection, documentation, and lithologic logging.

Sampling Personnel – Field team members responsible for physically collecting samples and decontamination of equipment.

Site Health and Safety Technician – The person who will use field screening instruments to monitor all field activities for VOCs and radiological contaminants and pre-shipment sample coolers.

4.0 Required Equipment

- Site-specific plans (i.e., FSP Addendum)
- Health and safety plan
- Field logbook
- Photoionization detector with appropriate lamp rating
- Calibration gases in a range appropriate for the expected use
- Pint- to quart-sized zip-top plastic bags
- Waterproof black ink pen
- Personal protective clothing and equipment

5.0 Procedures

5.1 Direct Reading Measurement

1. Charge the instrument overnight.

2. Connect the measurement probe to the instrument (if necessary), turn on the probe, and make necessary operational checks (e.g., battery check) as outlined in the manufacturer's manual.

3. Calibrate the instrument using appropriate calibration gas and following the applicable manufacturer's manual.

4. Make sure the instrument is reading zero and all function and range switches are set appropriately.

5. Prior to the start of sampling, a background reading shall be made at the surface of the location to be sampled. Read the total organic vapor concentration in parts per million (ppm) from the instrument display. Apply the appropriate correction factor if necessary. Record the highest instrument response.

6. While sampling, hold the tip of the probe within the samplers breathing zone, and read the total organic vapor concentration in parts per million (ppm) from the instrument display. Apply the appropriate correction factor if necessary. Record the highest instrument response.

7. For samples collected using a slide hammer, measurements will be made from the bottom end of the sampling liner or

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from auger cuttings placed into a plastic bag. Record the measurements in the field logbook or on appropriate field form.

8. For subsurface samples, once the acetate sleeve is split open, the entire cut surface of the core will be screened with the PID. Based on the measurements, the soil in the sleeve will be sampled in accordance with SSFL SOP 4. If measurements are made on any soil sample above background, headspace measurements will be made in accordance with the next section to determine the maximum VOC reading achieved. Record all measurements in the field logbook or on the appropriate field form.

5.2 Headspace Measurement

1. Once on and operational, calibrate the instrument (as needed) following the appropriate manufacturer's manual.

2. Make sure the instrument is reading zero and all function and range switches are set appropriately.

3. Fill one zip-top plastic bag approximately one-half full of the sample to be measured. Quickly seal the bag minimizing volume of air in bag.

4. Allow headspace to develop for approximately 10 minutes. It is generally preferable to knead the bag for 10 to 15 seconds to break apart the sample and maximize sample surface area.

Note: When the ambient temperature is below 0 degrees Celsius (32 degrees Fahrenheit), perform the headspace development and subsequent measurement within a heated vehicle or building.

5. Quickly puncture the bag wall and insert the probe, wrapping the bag wall around the probe stem to minimize loss of vapors. Insert the instrument probe to a point approximately one-half of the headspace depth. Do not let the probe contact the soil, and ensure the probe does not get plugged by the plastic during puncturing. If using a PID and there is condensation on the inside of the bag, only leave the probe in the jar or bag long enough to obtain a reading. Remove the probe and allow fresh air to flow through the instrument to avoid excess water vapor build-up.

6. Read the total organic vapor concentration in ppm from the instrument display. Apply the appropriate correction factor if necessary. Record the highest instrument response.

7. Immediately record the reading in the field logbook or on the appropriate field form.

6.0 Restrictions/Limitations

The PID provides quantitative measurement of total organic vapors, but generally is not compound-specific. The typical measurement range of the PID is 0 to 2,000 ppm. In addition, the instrument will not detect/measure VOCs with an associated ionization potential (in eVs) above the rating of the lamp, so lamp rating is critical to monitoring for selected VOCs.

Note: The presence of methane will cause erratic PID measurements.

7.0 References

No references were used in development of this SOP.

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Field Measurement of Residual Radiation

SSFL SOP 7
Revision: 0
Date: April 2012

Prepared: J. Sobol **Technical Review:** D. Chambers, C. Zakowski

QA Review: J. Oxford **Approved and Issued:** 4/6/2012
Signature/Date

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to define the techniques and the requirements for the detection of residual radiation in the breathing zone and in soil at the Santa Susana Field Laboratory (SSFL). The Department of Energy (DOE) surface contamination criteria are also defined herein with footnotes which reflect acceptable approaches for demonstrating achievement of such criteria.

2.0 Background

2.1 Definitions

MicroR detector–A portable, hand-held scintillation counter that measures gamma radiation in air. Although measurements are typically made about one meter above the ground surface, such sodium iodide scintillation detectors can also be used qualitatively measure radiation emitted from soil samples and soil cores. In this instance the detectors will be held about 0.5 to 1 inch above the samples. When used to evaluate soil sample activity, measurements will be compared against background count rates for the same material taken in a consistent manner (i.e., 0.5 to 1 inch above soil material). Background is established by taking measurements in an area that produced count rates that are relatively low and uniform.

Dual Phosphor Alpha Beta Scintillator–A portable, hand-held field radiation survey instrument that may detect alpha and beta emissions and, with proper calibration, can measure gamma emissions.

2.2 Associated Procedures

- SSFL SOP 1, *Procedures for Locating and Clearing Phase 3 Samples*
- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology (DPT)Sampling*
- SSFL SOP 5, *Backhoe Trenching/Test Pits for Sample Collection*
- SSFL SOP 9, *Lithologic Logging*

2.3 Discussion

Radiation screening of soil samples and ambient air is necessary because of the prior use of Area IV for nuclear research. Radiation measurement data will be used pursuant to health and safety monitoring to determine if radiation exposure rates for field personnel in a work area is acceptable or if additional personal protective equipment or exposure limitations are necessary for field personnel. In addition to health and safety monitoring, radiation monitoring will be used to screen surface and subsurface soil and sediment samples for levels above background. Background readings are important because they provide a point of departure for elevated readings.

Two types of instruments will be used to measure residual radiation: the MicroR gamma detector and Dual Phosphor alpha/beta detector.

2.3.1 MicroR Operation

The MicroR detector is a scintillation meter used to measure low levels of gamma radiation. Although sodium iodide detectors can be set up to operate as a single channel analyzer, thereby reporting a specific radionuclide, the instruments for this project will be set up to report all gamma emissions, irrespective of radionuclide. The instrument has a speaker which provides an audible measure of the radiation emitted, as an audible click. The rate at which the clicks occur allows real-time monitoring of the strength of the radiation sources. Readout is generally in terms of microroentgens per hour

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(µR/hr).These instruments are energy dependant, commonly over-responding by as much as a factor of 8 or more for lower energy gamma emissions and under-responding by about 20 percent for cobalt-60.

2.3.2 Dual Phosphor Alpha Beta Scintillation Operation

For this project a Model 43-89 Dual Phosphor alpha/beta scintillation detector will be primarily used to detect alpha/beta emissions.

Although these detectors can also detect alpha emissions, alpha particles generally have a range of about an inch or less in air with relatively few able to penetrate the detector window such that they are counted. Alpha/beta detectors are generally calibrated to the gamma emissions of cesium-137 with instrument response being energy dependent. Beta efficiency also varies with energy such that 4 pi efficiency ranges from about 13 percent to 50 percent for beta particles with average energies of 50 and 550 kiloelectron volts (keV), respectively. If the instrument has a speaker, the pulses also give an audible click. The readout can be displayed in multiple different units (e.g., roentgens per hour (R/hr), milliroentgens per hour (mR/hr), rem per hour (rem/hr), millirem per hour (mrem/hr), and counts per minute (cpm)) when the control switch is in the "Ratemeter" position. Alpha/beta probes including, the pancake type, are commonly used with a variety of different hand held scalers/ratemeters for contamination measurements. Given the energy dependence of the instruments and their variable response to different types of radiation, radiation control/health physics personnel should be consulted if any activity exceeding instrument background is detected.

3.0 Responsibilities

Field Team Leader–The field team leader (FTL) is responsible for ensuring that field personnel conduct field activities in accordance with this SOP and the Field Sampling Plan [FSP] Addendum.

Site Health and Safety Technician–The person who will use field screening instruments to monitor all field activities for VOCs and radiological contaminants and pre-shipment sample coolers. This person is a trained radiological technician who works under the guidance of Science Application International Corporation's (SAIC's) Certified Health Physicist (CHP).

Certified Health Physicist–The person who oversee radiation survey activities, confirm background levels, and provide field direction when background levels are exceeded per the Health and Safety Plan.

4.0 Required Equipment

- Ludlum Model 19 or Model 192 Micro R Detector (or equivalent)
- Ludlum Model 43-89 Dual Phosphor Alpha/Beta Scintillation Detector (or equivalent)[1]
- Site-specific plans (i.e., FSP Addendum)
- Health and safety plan (HASP)
- Field logbook
- Waterproof black ink pen
- Personal protective clothing and equipment

5.0 Determination of Radiation Background

As set forth in the HASP (health and safety plan monitoring and action levels) and for the selection of soil sample intervals (SSFL SOP 2, 3, 4, and 5), background radiation levels for various media will be established prior to soil sampling. Because radiation levels vary based on composition of the media and multimedia that will effect radiation measurements at the site, the following background radiation levels will be developed initially at the site.

- Unconsolidated soil
- Bedrock

[1] Ludlum Model 2360, Ludlum Model 26

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- Concrete slab/rubble
- Asphalt

Additional media may be added as it is encountered in the field. Background of these media will be established using the following procedure.

1. Ensure instrument is functioning properly and check source readings are acceptable per requirements of this SOP.
2. Demarcate background radiation SAMPLE AREA for each media with wooden Stakes. The Area IV background survey location established by EPA will serve as a starting point. Minimum requirements for the background SAMPLE AREA is as follows:

    a. 20 square feet of surface area

    b. made up of 80% intended media

    c. area does not consist of imported fill or debris

    d. area is absent of contamination (identified by visually inspection, and from EPA HSA, EPA gamma surveys, EPA soil sample results, RFI and Co-located Chemical data)

3. Obtain and Record GPS coordinates of SAMPLE AREA
4. Using appropriate radiation instrument (Micro R Meter Model 19/192, Dual Phosphor Alpha/Beta Detector Model 43-89) collect 10 gamma, alpha, and beta measurement about 0.5 to 1 inch above the media, equally distribute throughout the SAMPLE AREA. Each measurement will be at least 1 minute in duration.
5. Record the ten radiation measurements in log book.
6. Following collection of background measurements, ensure instrument is functioning properly and check source readings are acceptable per this SOP.
7. Discuss readings with site Certified Health Physicist (SAIC) for review and receive approval of background radiation level.
8. The Certified Health Physicist will provide approved background radiation level for the media to DOE and CDM Smith. This will include background level, mean, and standard deviation.
9. CDM Smith FTL will record the Certified Health Physicist's recommendations and discuss the background action level with all field personnel as part of safety briefings.
10. Following establishment of, and periodical renewal of background readings throughout project, background radiation levels will be discussed during project meetings and daily tailgate safety meetings.

6.0 Procedures

6.1 MicroR Detector

Background Gamma Scan

1. Prepare the instrument and check batteries. The meter needle should move to area on scale marked battery, indicating the batteries are good.
2. Measure background radiation level away from sample and source area. Measure the background radiation for approximately 60 seconds to allow determination of the range and relative mean background exposure rates and write

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down the readings. Note that background commonly ranges from about 5 to 20 µR/h, but can be higher as a result of increased elevation or higher concentrations of naturally occurring radioactive materials. In addition, it is often necessary to reevaluate background for different areas within the site. Upon completion of background determination, verify proper instrument operation using a National Institute of Standards and Technology (NIST) traceable check source to confirm proper instrument operation.

Surface Soil Gamma Scan

1. Beginning at the highest scale, proceed to lower scales until a reading is encountered. Set the instrument selector switch to the most sensitive range of the instrument. Holding the probe approximately 0.5 to 1 inch from the surface soil sample, move the detector slowly (about 1 inch per second) over the core and/or sample being evaluated with the detector parallel to the length of the core.

2. Do not let the probe touch anything and try to maintain a constant distance.

3. Areas that register more than background levels may be considered contaminated and a health physicist should be consulted.

6.2 Dual Phosphor Alpha/Beta Scintillation Detector

Background Alpha/Beta Scan

1. Prepare the instrument and check batteries. The meter needle should move to area on scale marked battery, indicating the batteries are good. Measure background radiation level away from source area.

2. Measure the background radiation at 0.5 to 1 inch above the media for ten 2-minute counting periods and record each of the readings. Background commonly ranges from about 5 to 20 µR/h but can be higher as a result of increased elevation or higher concentrations of naturally occurring radioactive materials.

3. Obtain ten 1-minute source activity measurements using a NIST traceable source of the appropriate beta energy.

4. Upon completion of the background and source efficiency counts, input the associated data into the spreadsheet provided to determine parameter limits (e.g., background and source efficiency within 20 percent of the mean). Subsequent counts of both background and source efficiency should be performed daily before instrument use, at the end of each duty day, and any time that instrument operation is questionable.

Soil Sample Beta Scan

1. Set the instrument selector switch to the most sensitive range of the instrument.

2. Holding the probe approximately 0.5 to 1 inch from the sample and move the probe slowly (about 1 inch per second). (***Note***: Alpha emissions are reliably detectable only with the detector as close as practicable to the item being surveyed. In addition, it should be noted that variation in beta background can preclude the ability to detect alpha emissions at levels prescribed in 10 CFR 835, Appendix D.)

3. Do not let the probe touch anything and try to maintain a constant distance.

4. Areas that register more than background level may be considered contaminated and a health physicist should be consulted.

Surface Contamination Scanning

In addition, every sample, piece of equipment, and container of material used at the site and/or that leaves the site will be surveyed and results will be used to document that residual total and removable surface contamination are compliant with criteria contained in Appendix D, 10 CFR 835. I

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Surface Contamination Values[1] in dpm/100 cm^2 Radionuclide	Removable [2, 4]	Total (Fixed + Removable) [2, 3]
U-nat, U-235, U-238, and associated decay products	1,000[7]	5,000[7]
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20	500
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above [5]	1,000	5,000
Tritium and STCs [6]	10,000	See Footnote 6

1. The values in this appendix, with the exception noted in footnote 6 below, apply to radioactive contamination deposited on, but not incorporated into the interior or matrix of, the contaminated item. Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides apply independently.

2. As used in this table, disintegrations per minute (dpm) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

3. The levels may be averaged over one square meter provided the maximum surface activity in any area of 100 cm^2 is less than three times the value specified. For purposes of averaging, any square meter of surface shall be considered to be above the surface contamination value if: (1) from measurements of a representative number of sections it is determined that the average contamination level exceeds the applicable value; or (2) it is determined that the sum of the activity of all isolated spots or particles in any 100 cm^2 area exceeds three times the applicable value.

4. The amount of removable radioactive material per 100 cm^2 of surface area should be determined by swiping the area with dry filter or soft absorbent paper, applying moderate pressure, and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. (Note—The use of dry material may not be appropriate for tritium.) When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area shall be based on the actual area and the entire surface shall be wiped. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

5. This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.

6. Tritium contamination may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may migrate to the surface in order to ensure the surface contamination value provided in this appendix is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a "Total" value does not apply. In certain cases, a "Total" value of 10,000 dpm/100 cm^2 may be applicable either to metals, of the types which form insoluble special tritium compounds that have been exposed to tritium; or to bulk materials to which particles of insoluble special tritium compound are fixed to a surface.

7. These limits only apply to the alpha emitters within the respective decay series.

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[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59688, Nov. 4, 1998; 72 FR 31940, June 8, 2007; 74 FR 18116, Apr. 21, 2009]

7.0 Restrictions/Limitations

Micro R and Dual Phosphor detectors are principally used for the detection of presence of radionuclides above background, not measurement devices. They are prone to breaking if the thin entrance window (found on pancake and end-window designs) is punctured. This can easily occur if the window comes in contact with a variety of objects (such as a blade of grass, paper clip, nail, and paint flecks). Once the window is broken the instrument ceases to operate and must, therefore, be returned for repair and calibration.

8.0 References

Integrated Environmental Management, Inc., 1998, *Measuring Radioactivity*

Oak Ridge Institute for Science and Education and Radiation Emergency Assistance Center/Training Site (REAC/TS), 1992, *Using a Typical Geiger-Mueller (GM) Counter to Survey*

Title 10, Code of Federal Regulations, Part 835, Occupational Radiation Protection

DOE Standard Radiological Control, DOE-STD-1098-2008 with change 1 dated May 2009

DOE Order 426.2, Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities, 21 April 2010

DOE Standard 1107-97 with Change 1 dated November 2007, Knowledge, Skills, and Abilities for Key Radiation Protection Positions

Ludlum Measurements, Inc. Operators Manuals for Model 2241 Survey Meter with Model 19/192 Detector

Ludlum Measurements, Inc. Operators Manuals for Model 43-80 Alpha/Beta Scintillator

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Field Data Collection Documents, Content, and Control

SSFL SOP 8
Revision: 1
Date: December 2012

Prepared: D. Lange
Technical Review: C. Werden
QA Review: J. Oxford
Approved and Issued: 12/7/2012
Signature/Date

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to set criteria for content entry and form of field logbooks and the SSFL Field Sample Data Sheet (FSDS) used to document field work at the Santa Susana Field Laboratory (SSFL) site. The FSDS is also used for data entry into the Scribe database.

2.0 Background

A permanently bound and consecutively paginated field logbook will be maintained daily by the CDM Smith field team in accordance with the procedures below.

2.1 Discussion

Information recorded in field logbooks includes field team member names, visitors, observations, data, calculations made onsite, date/time, weather, and description of the data collection activity, methods, instruments, and results. Additionally, the logbook must contain deviations from plans, observations of fill, and site features including sketches, maps, or drawings as appropriate. In addition, all SOPs will be on hand with the field sampling team.

2.2 Associated Procedures

- SSFL SOP 1, *Procedures for Locating and Clearing Phase 3 Samples*
- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology Sampling*
- SSFL SOP 5, *Backhoe Trenching/Test Pits for Sample Collection*
- SSFL SOP 9, *Lithologic Logging*
- SSFL SOP 14, *Geophysical Survey*
- SSFL SOP 15, *Photographic Documentation of Field Activities*
- SSFL SOP 16, *Control of Measurement and Test Equipment*

3.0 General Responsibilities

Field Team Leader (FTL)–The FTL is responsible for ensuring that the format and content of data entries are in accordance with this procedure. The FTL will provide field logbooks and FSDSs to the site geologist who will be responsible for their care and maintenance while in his or her possession.

Site Geologist–The site geologist is responsible for documenting site activities into the logbook and completing a FSDF for each soil sample collected. .

Other Site Personnel–All CDM Smith employees who make entries in field logbooks during onsite activities are required to read this procedure before engaging in this activity. Site personnel will return field logbooks to the FTL at the end of the assignment.

4.0 Required Equipment

- Site-specific plans (Field Sampling Plan [FSP] Addendum, health and safety plan, and all SSFL SOPs)
- Field logbook
- Scribe Version 3.8 (or later)
- Indelible black or blue ink pen
- SSFL Field Sample Data Sheet (FSDS)

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Field Data Collection Documents, Content, and Control

SSFL SOP 8
Revision: 1
Date: December 2012

5.0 Procedures

5.1 Preparation

In addition to this SOP, site personnel responsible for maintaining logbooks must be familiar with all procedures applicable to the field activity being performed. These procedures should be consulted as necessary to obtain specific information about equipment and supplies, health and safety, sample collection, packaging, decontamination, and documentation. These procedures should be located at the field office and field vehicle for easy reference.

Field logbooks are bound, with lined and consecutively numbered pages. All markings and notes will be made with indelible black or blue ink pen. All pages must be numbered before initial use of the logbook. Before use in the field, the FTL will title and sequentially number each page of each logbook and set up the table of contents (TOC). Record the following information on the cover of the logbook:

- Field logbook number (if applicable).
- Site name and location.
- Activity (if the logbook is to be activity-specific).
- Start date of entries.
- End date of entries.
- Name of CDM Smith contact and phone number(s) (typically the project manager).

The first few (approximately two) pages of the logbook will be reserved for a TOC. Mark the first page with the heading "Table of Contents" and enter the following:

Table of Contents

Date/Description	Pages
(Start Date)/Reserved for TOC	1-2

The remaining pages of the TOC will also be designated as such with "Table of Contents" written on the top center of each page. The TOC should be completed as activities are completed and before returning the logbook back to the FTL.

5.2 Log Book Requirements

Documentation requirements for logbooks are:

- Record work, observations, quantity of materials, field calculations and drawings, and related information directly in the logbook. If data collection forms are specified by an activity-specific plan, this information does not need to be duplicated in the logbook. However, forms (e.g., SSFL-FSDSs) used to record site information must be referenced in the logbook.
- Do not start a new page until the previous one is full or has been marked with a single diagonal line so that additional entries cannot be made. Use both sides of each page.
- Do not erase or blot out any entry at any time. Indicate any deletion by a single line through the material to be deleted. Initial and date each deletion. Take care to not obliterate what was written previously.
- Do not remove any pages from the book.

Specific requirements for field logbook entries include:

- Initial and date each page.
- Sign and date the final page of entries for each day.
- Initial and date all changes.
- If authors change within the course of the day, the original author must insert the following:
  Above notes authored by:
  - (Sign name)
  - (Print name)
  - (Date)
- The new author must sign and print his/her name before additional entries are made.
- Draw a diagonal line through the remainder of the final page at the end of the day.

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- Record the following information on a daily basis:
  -Date and time
  -Name of individual making entry
  -Names of field team and other persons onsite
  -Description of activity being conducted including station or location (i.e., boring, sampling location number) if appropriate
  -Weather conditions (i.e., temperature, cloud cover, precipitation, wind direction and speed) and other pertinent data
  -Level of personal protection used
  -Serial numbers of instruments
  -Equipment calibration information (initial and ongoing date and time activity)
  -Serial/tracking numbers on documentation (e.g., carrier air bills)

Entries into the field logbook shall be preceded with the time (written in military units) of the observation. The time should be recorded frequently and at the point of events or measurements that are critical to the activity being logged. All measurements made and samples collected must be recorded.

A sketch of station location may be warranted. All maps or sketches made in the logbook should have descriptions of the features shown and a direction indicator.

Other events and observations that should be recorded include:
- Changes in weather that impact field activities.
- Deviations from procedures outlined in any governing documents. Also, record the reason for any noted deviation.
- Problems, downtime, or delays.
- Upgrade or downgrade of personal protection equipment.
- Visitors to the site.

5.3 Field Sample Data Sheets

- An example FSDS that will be use to record the sample details and subsurface conditions is included as Attachment 1 to SOP 8.
- The FSDS will be completed by the Site Geologist and include general from observations of the soil core, cuttings, and sidewalls of trenches and test pits.
- The FSDS is a single page, double-sided form that will be completed in indelible ink.
- All portions of the form will be completed. If any portion is not applicable to the activity being recorded, that portion will be crossed out with a single line and initialed by the Site Geologist.
- The FSDS must be reviewed and signed by another field team member before being copied into a pdf file.
- The pdf file will be transferred to CDM Smith's main database weekly by the sample coordinator. The original of the FSDS will be maintained in a binder at the site office until completion of all field activities.
- Sample description information (sample characteristics, presence of fill, staining, odor, etc.) will be transferred to the electronic database on a weekly basis by the FTL or sample coordinator or his/her designee.
- Copies of the FSDS documents will be included in the data report presenting the findings of the investigation.
- The completed FSDS form will be kept as a quality record in CDM Smith's SSFL project file for period of 10 years as stated in Section 7.9 of the Administrative Order on Consent.

5.4 Scribe Database Requirements

The Scribe database will be used to capture the data from the FSDS and perform the following tasks (at a minimum):
- Document field sample collection
- Generate chain of custody forms
- Track field samples to laboratories
- Query database and produce reports

- The FSDS information is entered into the field database, Scribe.
- The Scribe data entry is reviewed by another staff.
- The Scribe database is backed up daily off-site to CDM Smith servers. In the event of internet outages, the backups will

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be made to an external device such as an external hard-drive, thumb drive or CD/DVD. Once internet service is restored the most current backup will be used and placed on the CDM Smith servers.
- Changes to the finalized FSDS are documented on the FSDS and Scribe.

5.5 Photographs

Photography is restricted at SSFL. All cameras require permits from The Boeing Company (Boeing) to be onsite. Photographs may be taken at the site to visually document field activities and site features, as needed and in accordance with SSFL SOP 15. Digital photographs will be submitted to the electronic project files.

All digital photographs will be documented on a photographic log in the logbook or on a separate form (reference in the logbook). Captions must be added to the file name after the photographs are downloaded. The caption should be a unique identifier – number or date and short description. The photographic log should contain the following information:

- Photograph sequence number
- Description of activity/item shown (e.g., SSFL and sampling activity)
- Date and time
- Direction (if applicable)
- Name of photographer

5.6 Post-Operation

To guard against loss of data as a result of damage or disappearance of logbooks, photocopy or scan completed pages daily and forward to the field or project office weekly (at a minimum). Photocopy or scan other field records (e.g., Field Sample Data Sheets, photographic logs) weekly and upload to CDM Smith servers weekly (at a minimum), or as requested.

At the conclusion of each day, the individual responsible for the logbook will ensure that all entries have been appropriately signed and dated and that corrections were made properly (single lines drawn through incorrect information then initialed and dated). Completed logbooks will be returned to the FTL.

6.0 Restrictions/Limitations

Field logbooks constitute the official record of onsite technical work, investigations, and data collection activities. Their use, control, and ownership are restricted to activities pertaining to specific field operations carried out by CDM Smith personnel and their subcontractors. They may be used in court to indicate dates, personnel, procedures, and techniques employed during site activities. Entries made in these logbooks should be factual, clear, precise, and non-subjective. Field logbooks, and entries within, are not to be used for personal use.

7.0 References

No references used.

8.0 Attachments

Attachment A – SSFL Phase 3 – Field Sample Data Sheet

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SSFL Phase 3 – Field Sample Data Sheet

CDM Smith

FSDS Checked By _____

Sample ID _____ **Date/Time** _____

Matrix (circle one)
Soil Sediment Water

Start Depth _____

End Depth _____

Depth Units (circle one)
Inches Feet

Check if Composite ☐

Collection Method (circle one)
DPT Slide Hammer Hand Auger/Slide Hammer Trenching Sediment

QC Type (circle one)
N FD FB RB

Parent Sample ID _____

Field Geologist _____

Sampler _____

Analysis

	Parameters	Method	Analyze?
	Metals	EPA 6010	
		EPA 6020	
		EPA 7471 (Soil)	
		EPA 7470 (Water)	
	Fluoride	EPA 300.0/9056	
	SVOCs	EPA 8270	
	TIC	EPA 8270	
	PAHs	EPA 8270 SIM	
	1,4 Dioxane	EPA 8270 SIM	
	Dioxins	EPA 1613	
	PCBs/PCTs	EPA 8082	
	Perchlorate	EPA 314.0/331	
	Perchlorate Confirmation	EPA 6850/6860	
	pH	EPA 9045 (Soil)	
		EPA 9040 (Water)	
	Hexavalent Chromium	EPA 7196/7199	
	Herbicides	EPA 8151	
	Pesticides	EPA 8081	

	Parameters	Method	Analyze?
Encores	VOCs	EPA 8260	
	1,4 Dioxane	EPA 8260 SIM	
	TPH-GRO	EPA 8015	
	TPH-EFH	EPA 8015	
	Glycols	EPA 8015	
	Alcohols	EPA 8015	
	Terphenyls	EPA 8015	
	Nitrates	EPA 300.0/9056	
	Energetics	EPA 8330	
	Cyanide	EPA 9012	
	Formaldehyde	EPA 8315	
	NDMA	EPA 1625	
Sediment	Organotin	NOAA Status and Trends, Krone et al.	
	Methyl Mercury	EPA 1630	

NA – Not Applicable

SSFL Phase 3 – Field Data Sample Sheet (Sample Descriptions)

Soil Classification (circle one)

MAJOR DIVISION			GROUP SYMBOL	LETTER SYMBOL	GROUP NAME
COARSE GRAINED SOILS CONTAINS MORE THAN 50% FINES	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVEL WITH ≤ 5% FINES		GW	Well-graded GRAVEL
				GP	Poorly graded GRAVEL
		GRAVEL WITH BETWEEN 5% AND 15% FINES		GW-GM	Well-graded GRAVEL with silt
				GW-GC	Well-graded GRAVEL with clay
				GP-GM	Poorly graded GRAVEL with silt
				GP-GC	Poorly graded GRAVEL with clay
		GRAVEL WITH ≥ 15% FINES		GM	Silty GRAVEL
				GC	Clayey GRAVEL
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SAND WITH ≤ 5% FINES		SW	Well-graded SAND
				SP	Poorly graded SAND
		SAND WITH BETWEEN 5% AND 15% FINES		SW-SM	Well-graded SAND with silt
				SW-SC	Well-graded SAND with clay
				SP-SM	Poorly graded SAND with silt
				SP-SC	Poorly graded SAND with clay
		SAND WITH ≥ 15% FINES		SM	Silty SAND
				SC	Clayey SAND
FINE GRAINED SOILS CONTAINS MORE THAN 50% FINES	SILT AND CLAY	LIQUID LIMIT LESS THAN 50		ML	Inorganic SILT with low plasticity
				CL	Lean inorganic CLAY with low plasticity
				OL	Organic SILT with low plasticity
		LIQUID LIMIT GREATER THAN 50		MH	Elastic inorganic SILT with moderate to high plasticity
				CH	Fat inorganic CLAY with moderate to high plasticity
				OH	Organic SILT or CLAY with moderate to high plasticity
HIGHLY ORGANIC SOILS				PT	PEAT soils with high organic contents

Fill Material

1. Is Fill Material Present Yes No

2. Percentage Fill (%) _____

3. Fill Description (circle all that apply)

Asphalt Metal Plastic

Concrete Wood Glass

Igneous/Metamorphic Gravel N/A

Other _____

Is Staining Present Yes No

Color _____

Odor

1. Odor Strength (circle one)

None Slight Strong

2. Odor Description (circle one)

Organic Petroleum Chemical

N/A Other _____

Moisture Condition (circle one)

Dry Moist Wet

PG Signature _____ **PG Registration #** _____

Additional Comments _____

NA – Not Applicable

Lithologic Logging

SSFL SOP 9
Revision: 1
Date: June 2012

Prepared: D. Lange

Technical Review: C. Werden

QA Review: J. Oxford

Approved and Issued: 6/12/2012
Signature/Date

1.0 Objective

This technical standard operating procedure (SOP) governs basic lithologic logging of surface and subsurface soil samples collected during field operations at the Santa Susana Field Laboratory (SSFL) site. The purpose of this SOP is to present a protocol and standardized documentation format for lithologic observations. Protocols for recording basic lithologic data including, but not limited to, soil types (per the Unified Soil Classification System [USCS] classification), presence of fill (and associated deleterious materials), lithologic names, color, moisture, density, contacts, and secondary features such as organic material and fractures.

The goal of this SOP is to have consistent descriptions of the subsurface materials.

2.0 Background

The local geology of SSFL is well characterized; thousands of shallow boreholes and excavations have been completed. Lithologic information about soil, rock, and fill assists in the understanding of subsurface conditions, moisture infiltration, groundwater flow, and potential contaminant migration pathways.

As such, detailed lithologic logs are not necessary. The primary goal of lithologic logging at SSFL is to document the stratigraphic sequence, the presence of fill or native soil, occurrence and type of debris and/or staining, associated PID and radiological screening values, and deviations from the normal or anticipated stratigraphic section.

2.1 Definitions

The following list corresponds to the description sequences outlined in Section 5.2.1. An example lithologic log is included in Attachment A.

Name of Sediment or Rock – In naming unconsolidated sediments, the logger shall describe the grain size, distribution, color, and moisture content, and determine the presence of fill materials. In naming sedimentary rocks (only type of bedrock anticipated at SSFL), the logger shall examine the specimen for mineralogy and use the appropriate rock description.

Color - Color will be determined using the appropriate Munsell color chart (soil or rock) and listing the Munsell number that corresponds to the color. If an unconsolidated material is mottled in color, the ranges in color shall be described. When describing core samples with several individual colors, individual color names shall be listed and an overall best color name shall be given.

Degree of Consolidation – The degree of consolidation refers to how well the material has been indurated. Unconsolidated sediments may be compacted somewhat and should be described as loose, moderately compacted, or strongly compacted. In some cases they may be slightly cemented by caliche and should be described as slightly cemented, moderately cemented, or strongly cemented. Sedimentary rocks are typically indurated, but may vary in the degree of cementation. These rocks should be described as friable, moderately friable, or well indurated. If the logger believes he/she can identify the cementing material, then it shall be included in the description.

Moisture Content – Moisture content refers to the amount of water within the sediment or the matrix. Sedimentary rocks and unconsolidated sediments may have associated moisture within and should be described as dry, moist, or wet.

Evidence of Contamination – The logger should examine the sample/core and note any obvious signs of contamination such as streaking, free product, odor, or discoloration. These observations will be noted in the field book and on the lithologic log, as well as screening measurements from the photoionization detector (PID) and radiation (alpha, beta) probes.

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Description of Contacts – The logger will note changes in lithology. These changes may be gradational contacts within sediments or may be sharp contacts such as sediments over rocks. The logger should describe whether the contacts are gradational or sharp, and note the depth below the surface.

Composition – The composition of the rock refers to the mineralogy of the material encountered. The logger should describe the mineralogy, if it can be determined.

2.2 Associated Procedures

- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology Sampling*
- SSFL SOP 5, *Backhoe Trenching/Test Pits for Sample Collection*
- SSFL SOP 8, *Field Data Collection Documents, Content, and Control*

2.3 Discussion

The subsurface sampling techniques used at SSFL (i.e., slide hammer, hand auger, DPT rigs, and trenching) all result in soil/rock being brought to the surface for description and logging. The soil boring, core retrieval, and lithologic logging will be conducted under the guidance of a California professional geologist or engineer. An important aspect of soil sampling is the identification and differentiation of native soil/rock from fill material. To help in this task, it is important to use the USCS classification scheme, and uniform and consistent descriptions. Soil and rock descriptions will be consistent with ASTM D2488-09a (Standard Practice for Description and Identification of Soils – Visual Manual Procedure). This SOP also provides a sequence for recording information on a standardized log form to make descriptions as uniform and consistent as possible. All SOPs will be in the possession of the field crew during drilling.

3.0 General Responsibilities

Field Team Leader (FTL) – The FTL is responsible for maintaining logbooks and qualified field staff.

Site Geologist – Individual responsible for describing and logging of all soil cuttings/samples and all rock per this SOP. A California professional geologist or engineer is required to lead this project work.

4.0 Required Equipment

The description of subsurface lithologies requires a minor amount of field equipment for the geologist. This section provides a list of equipment to be used by the lithologic logger but does not include equipment such as drill rigs, PID, sampling equipment, and personal protective equipment. The following is a general list of equipment that may be used:

- Field logbook and lithologic log form
- Clipboard
- Munsell color chart for soil
- Munsell color chart for rock
- Dilute (10 percent) hydrochloric acid, as desired
- Waterproof pens
- 10x magnifying hand lens
- Knife or cutting tool
- Zip-top baggies
- Reference field charts, as desired

5.0 Procedures

5.1 Office

- Obtain field logbook and lithologic log forms
- Coordinate schedules/actions with FTL
- Obtain necessary field equipment (see above)
- Review field support documents (i.e., Field Sampling Plan [FSP] Addendum, health and safety plan)
- Review applicable geologic references such as historic lithologic logs from the site and/or geologic maps, as needed

5.1.1 Documentation

Record observations at each sampling location on individual SSFL lithologic log forms (Attachment A). In preparing the

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logging form, the site geologists (i.e., lithologic loggers) will follow the general procedures for keeping a field logbook (SSFL SOP 8). All blanks in the lithologic log form must be filled out; if an item is not applicable, an "NA" shall be entered.

The Lithologic Log Form shall be filled out according to the following instructions. The front page of the form contains general information including, but not limited to:

- The project name, sample location, and subarea.
- Date that the drilling activity was started and completed
- Name of the person logging along with the beginning depth-end depth (in feet)
- Borehole diameter(s) and drilling methods
- Name and company of the driller and the type of sampling tool used

A map showing the soil sampling location may be attached.

The continuation page(s) of the log form should be completed according to the instructions provided within this section and according to the sequence provided in Section 5.2.1. The depth column refers to the depth below ground surface (bgs) in feet. The tick marks can be arbitrarily set to any depth interval depending on the scale needed except where client requirements dictate the spacing. The "USCS" column shall contain the USCS soil type/rock type; schematic symbols are not required. Use a single X to mark the area where no core was recovered, and notes shall be recorded as to why the section was not recovered. Sharp or abrupt contacts between lithologies will be indicated by a solid horizontal line. Gradational changes in lithologic composition should be noted. PID and radiation measurements will be recorded within the "PID" and "Radiological" columns at the appropriate depths. The "Description of Materials" column, where the lithology is described, is the most important part of the lithologic log. In completing this section, use the applicable reference charts and complete according to the sequence in Section 5.2.1. The "Sample Name" column is reserved for noting any samples taken and submitted to the laboratory. The sample number shall be filled in at the appropriate depth. The "Recovery" column is where the core recovery is noted as feet recovered over the sample interval (i.e., "4/4" means that all four feet of core was recovered over the four foot core interval).

In addition to the information on the log form, the geologist will record the appropriate information into the logbook when there is a rig shutdown, rig problems, failure to recover core, or other issues.

5.2 General Guidelines for Using and Supplementing Lithologic Descriptive Protocols

This SOP is intended to serve as a guide for recording basic lithologic information. The descriptive protocol presented here must be followed in making basic observations. Selected information charts may be used for classification and naming of rock, sediment, and soil. Some observations will be common to all rock and soil descriptions. All descriptions shall include as appropriate: name of sediment or rock, color (using the Munsell color charts), moisture content, composition, significant inclusions, and degree of consolidation or induration, and the presence and type of fill materials, if identified. The description of each category shall be separated by a semicolon.

Describe all unconsolidated sediment and soil according to the USCS. Abbreviations may be used for often-repeated terminology when recording lithologic descriptions. Several commonly used abbreviations are included at the bottom of the log. Additional abbreviations and their meaning must be added to this list. Loggers are cautioned to limit the use of abbreviations to avoid a lithologic log that is cryptic.

5.2.1 Protocols for Lithologic Description of Discrete Soil or Rock Cores

This section describes the protocols for completing a lithologic description based on discrete soil or rock core samples. For instance, in a 5-foot soil core, the dominant lithology may be siltstone that is interrupted by several thin beds of another lithology such as gravel. This section description can be simplified by writing: 5-10 bgs = siltstone (with other descriptors) except as noted; 7-8 foot gravel zone (with descriptors); 8-9 foot pebble zone (with descriptors); etc. This also aids in "seeing" the thickest unit designations possible for use in modeling.

Description of Unconsolidated Material

Unconsolidated material comprises the majority of the subsurface interval for the Phase 3 investigation. The shallow subsurface is very important to the chemical characterization because of infiltration and migration. Soils are to be described as

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unconsolidated material and will include:

- Name of sediment (sand, silt, clay, etc.)
- Grain size and distribution
- Composition of larger-grained sediments
- Color (per Munsell color chart)
- Degree of consolidation and cementation
- Moisture content
- Density
- Description of contacts

In accordance with the USCS on naming unconsolidated sediment, the particle size with the highest percentage is the root name. When additional grains are present in excess of 15 percent, the root name is modified by adding a term in front of the root name. For instance, if a material is 80 percent sand and 20 percent gravel, then it is gravelly sand. If the subordinate grains comprise less than 15 percent but greater than 5 percent, the name is written: _____(dominant grain) with _____(subordinate grain). For example, a soil with 90 percent sand and 10 percent silt would be named a sand with silt. If a soil contains greater than 15 percent of four particle sizes, then the name is comprised of the dominant grain size as the root name and modifiers as added before. For example, if a material is 60 percent sand, 20 percent silt, and 20 percent clay the name would be a silty clayey sand. If a material is 70 percent sand, 20 percent silt, and 10 percent clay, it would be a silty sand with clay. When large cobbles or boulders are present, their percentage shall be estimated and their mineralogy recorded.

5.3 Post-Operation

On a weekly basis, all boring logs produced during that week shall be sent to the CDM Smith California PG. The PG will review the logs to ensure that they have been prepared in accordance with this SOP. If any revisions need to be made to any logs, they shall be returned to the field geologist for revision. If the boring log is acceptable, it will be signed by the PG and their registration number noted. All signed boring logs will be returned to the SSFL field office for the remainder of the field work.

6.0 Restrictions/Limitations

Only geologists, or similarly qualified persons trained in lithologic description, are qualified to perform the duties described in this SOP. The FTL for a project will have the authority to decide whether or not an individual is qualified.

7.0 References

ASTM D2488-09a Standard Practice for Description and Identification of Soils – Visual Manual Procedure

8.0 Attachments

Attachment A - SSFL Lithologic Log
Attachment B - Example of Unified Soil Classification System (USCS)
Attachment C - ASTM D2844-09a Standard

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Lithologic Logging

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Date: June 2012

Attachment A
Lithologic Log

Location ID:	Subarea:	Date Started:	Date Completed:
Client: DOE	Project Name/#: SSFL-65258-63376.1203.002.223.02231.SSPH3		Total Depth:
Company Name: CDM SMITH	Drill Contractor/Driller: NA		
GPS:	Drill Method:		Depth Drilled into Bedrock:
Radiological Background:	Borehole diameter:		
PID Background:	Depth to GW:		Sampling Method:
Radiological Equipment Used: ✓ MicroR ✓ Alpha/Beta ✓ Pancake	PG Review & No.:		Geologist: N.Begay

Depth (feet) bgs	Recovery (feet)	PID (ppm)	Radiological (µR/cpm)	Sample Name	Sample Time	USCS	Description of Materials

CDM Smith BORING LOG AND SAMPLING RECORD Page 1 of ___

ABBREVIATIONS:

amt: amount	gr: grained	pg: poorly graded	t: trace
c: coarse	lt: light	rnd: rounded	v: very
dk: dark	m: medium	sa: subangular	wg: well graded
f: fine	mod: moderate	sr: subrounded	ϕ: diameter

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Lithologic Logging

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Location ID:	Subarea:	Date Started:	Date Completed:
Project: SSFL		Geologist:	Total Depth:

Depth (feet) bgs	Recovery (feet)	PID (ppm)	Radiological (µR/cpm)	Sample Name	Sample Time	USCS	Description of Materials

CDM Smith

BORING LOG AND SAMPLING RECORD

Page___of___

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Attachment B
Example of Unified Soil Classification System (USCS)

Summary of USCS Field Identification Tests							
Coarse-Grained Soils **More than half the material (by weight) is individual grains visible to the naked eye.**	**Gravelly Soils** More than half of coarse fraction is larger than 4.75 mm.		**Clean Gravels** Will not leave a stain on a wet palm	Substantial amounts of all grain particle sizes			GW
				Predominantly one size or range of sizes with some intermediate sizes missing			GP
			Dirty Gravels Will leave a stain on a wet palm	Non-plastic fines (to identify, see ML below)			GM
				Plastic fines (to identify, see CL below)			GC
	Sandy Soils More than half of coarse fraction is smaller than 4.75 mm.		**Clean Sands** Will not leave a stain on a wet palm	Wide range in grain size and substantial amounts of all grain particle sizes			SW
				Predominantly one size or a range of sizes with some intermediate sizes missing			SP
			Dirty Sands Will leave a stain on a wet palm	Non-plastic fines (to identify, see ML below)			SM
				Plastic fines (to identify, see CL below)			SC
Fine-Grained Soils **More than half the material (by weight) is individual grains not visible to the naked eye.** **(<0.074 mm)**	**Ribbon**	**Liquid Limit**	**Dry Crushing Strength**	**Dilatancy Reaction**	**Toughness**	**Stickiness**	
	None	<50	None to Slight	Rapid	Low	None	ML
	Weak	<50	Medium to High	None to Very Slow	Medium to High	Medium	CL
	Strong	>50	Slight to Medium	Slow to None	Medium	Low	MH
	Very Strong	>50	High to Very High	None	High	Very High	CH
Highly Organic Soils	Readily identified by color, odor, spongy feel, and frequently by fibrous texture						OL OH Pt

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Attachment C
ASTM D2488-09a
Standard Practice for Description and Identification of Soils – Visual Manual Procedure

Designation: D2488 – 09a

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (either intact or disturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids
D1452 Practice for Soil Exploration and Sampling by Auger Borings
D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils
D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
D2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.
Current edition approved June 15, 2009. Published July 2009. Originally approved in 1966. Last previous edition approved in 2009 as D2488 – 09. DOI: 10.1520/D2488-09A.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

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Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-µm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D3740 provides a means for evaluating some of those factors.

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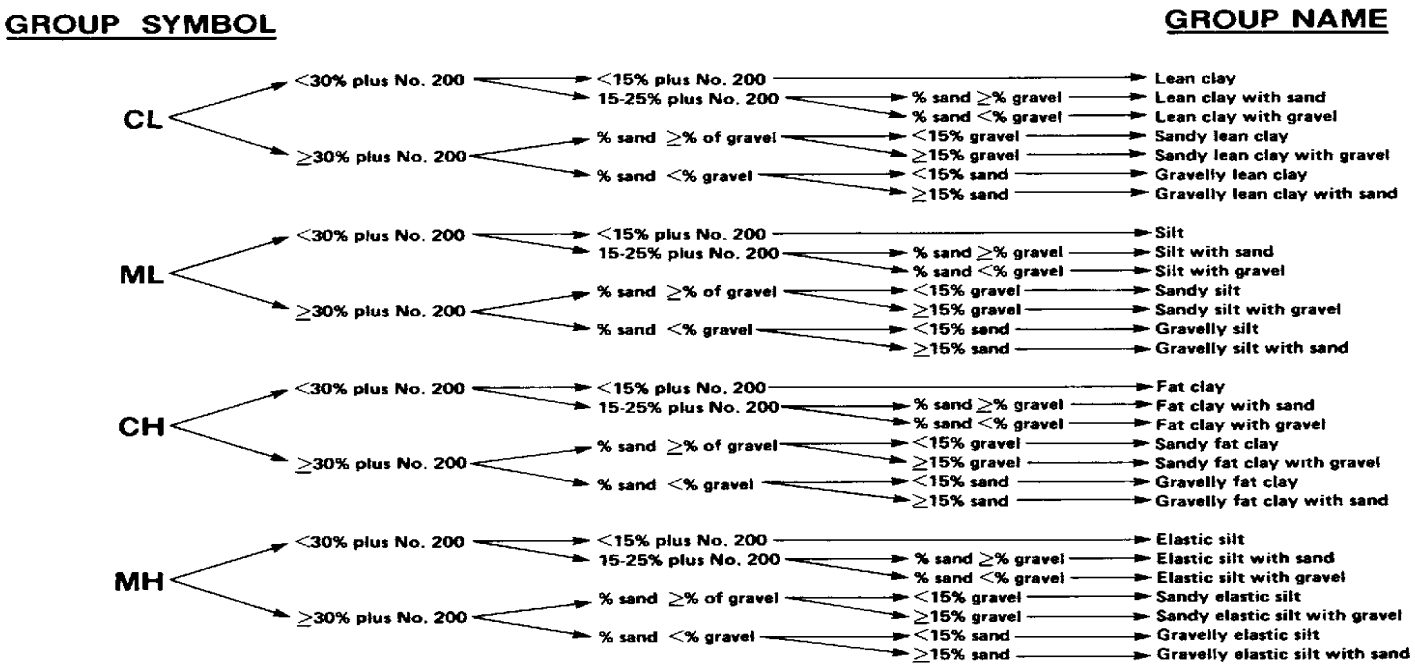
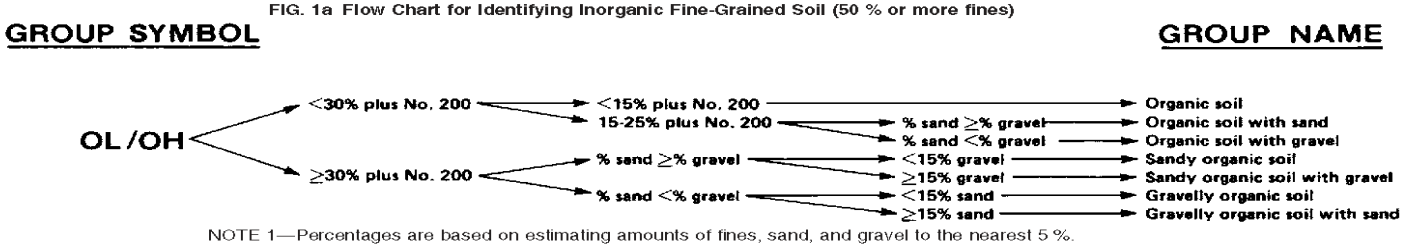


NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

6. Apparatus

6.1 *Required Apparatus*:
6.1.1 *Pocket Knife or Small Spatula.*
6.2 *Useful Auxiliary Apparatus*:
6.2.1 *Test Tube and Stopper* (or jar with a lid).
6.2.2 *Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D1452, D1587, or D2113, or Test Method D1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

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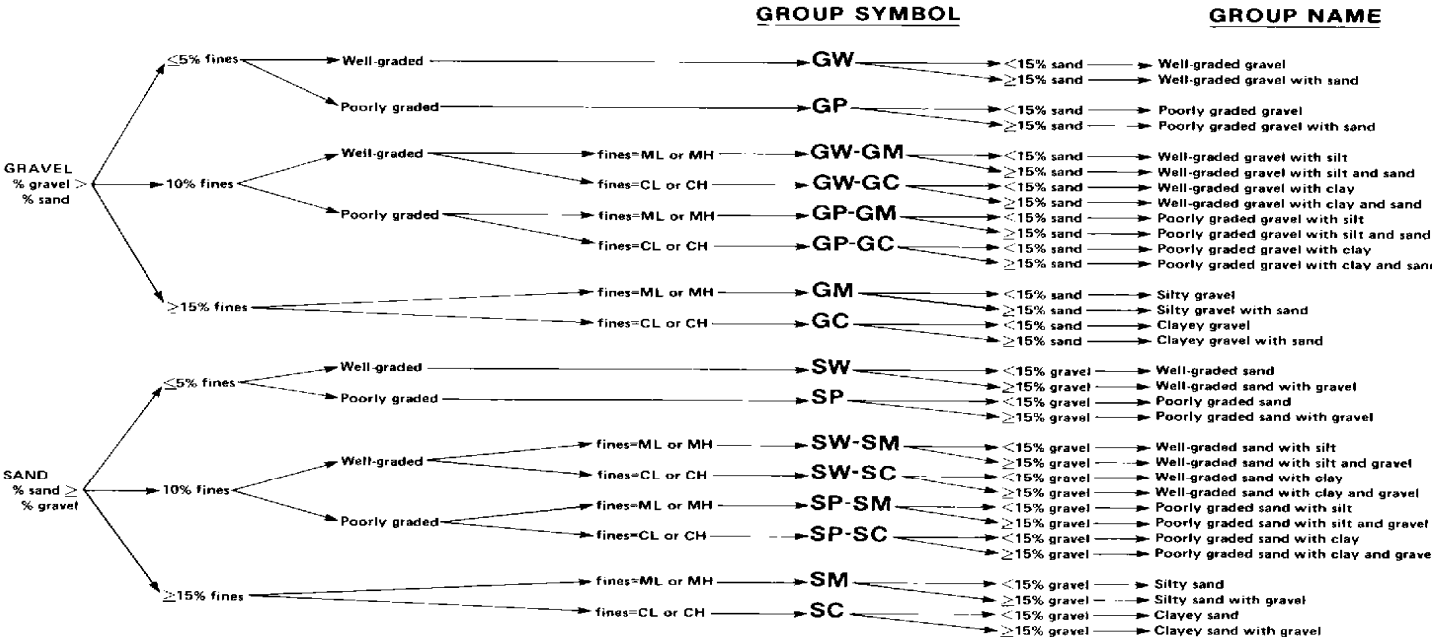

NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table

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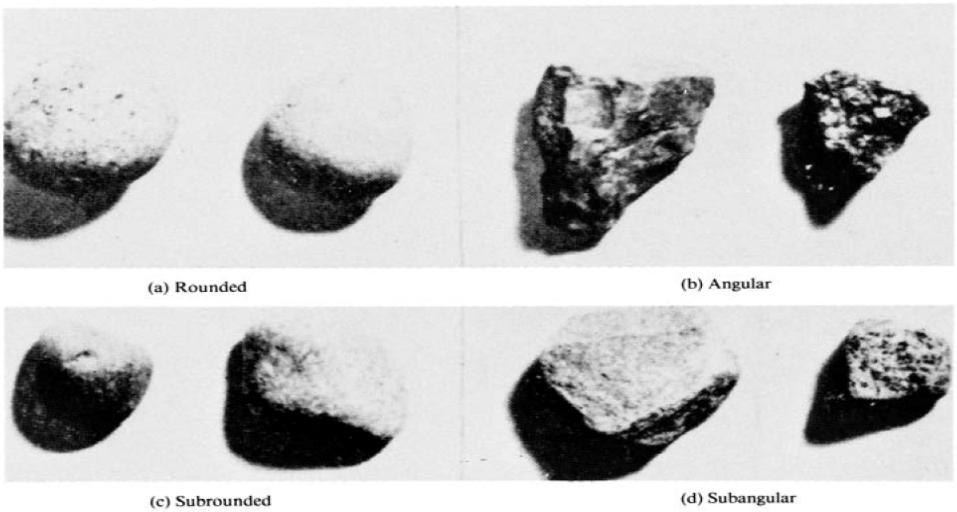

FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maxi-

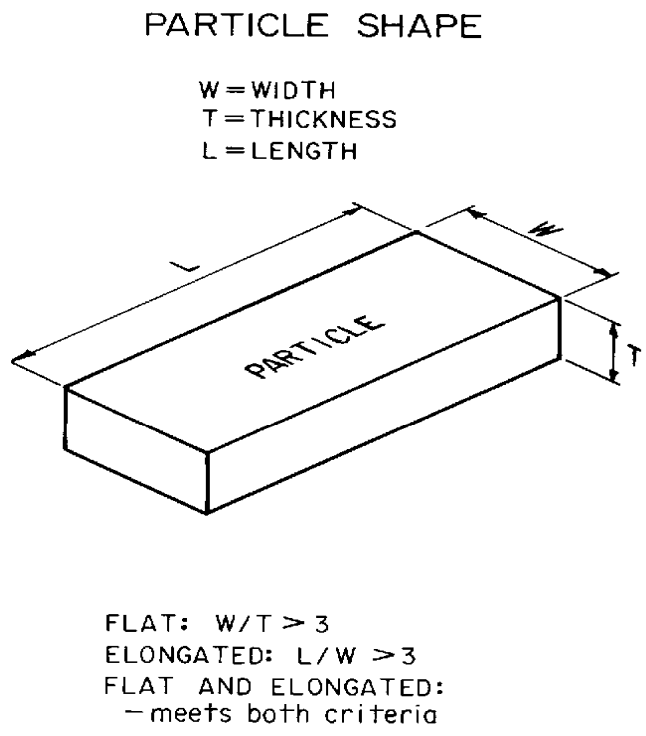

FIG. 4 Criteria for Particle Shape

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TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

mum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

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14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

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TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness and Plasticity
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils
(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

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TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

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X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown.

X2.4.3 *Broken Shells*—About 60 % uniformly graded gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % nonplastic fines; "Poorly Graded Gravel with Silt and Sand (GP-GM)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

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X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D2488 – 09) that may impact the use of this standard. (Approved June 15, 2009.)

(*1*) Revised Section 1.2.3.

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Sample Custody

SSFL SOP 10
Revision: 1
Date: November 2012

Prepared:	J. Sobol	**Technical Review:**	C. Werden
QA Review:	J. Oxford	**Approved and Issued:**	11/20/2012 *Signature/Date*

1.0 Objective

Because of the evidentiary nature of samples collected during environmental investigations, possession must be traceable from the time the samples are collected until their derived data are used to support remedial or other decisions. To maintain and document sample possession, sample custody procedures, as described in this technical standard operating procedure (SOP) are followed. All paperwork associated with the sample custody procedures at the Santa Susana Field Laboratory (SSFL) site will be retained in CDM Smith files unless Department of Energy (DOE) requests that it be transferred to them.

2.0 Background

2.1 Definitions

Sample – A sample is material to be analyzed that is contained in single or multiple containers representing a unique sample identification number.

Sample Custody–A sample is under custody if:

1. It is in your possession
2. It is in your view, after being in your possession
3. It was in your possession and you locked it up
4. It is in a designated secure area
5. It is in transit by a delivery or courier service

Chain-of-Custody Record–A chain-of-custody record is a form used to document the transfer of custody of samples from one individual to another. The forms are electronic and managed in the Scribe software. An example form is included in the Field Sampling Plan (FSP) Addendum and attached to this SOP.

Custody Seal–A custody seal is a tape-like seal that is part of the chain-of-custody process and is used to detect tampering with samples after they have been packed for shipping. Custody seals are placed on coolers not individual samples.

Sample Label– A sample label is an adhesive label placed on sample containers to designate a sample identification number and other sampling information.

2.2 Associated Procedures

- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology Sampling*
- SSFL SOP 5, *Backhoe Trenching/Test Pits for Sample Collection*
- SSFL SOP 8, *Field Data Collection Documents, Content, and Control*

3.0 General Responsibilities

Field Team Leader–The field team leader (FTL) is responsible for ensuring that strict chain-of-custody procedures are maintained during all sampling events. The FTL is also responsible for coordinating with the subcontract laboratory to ensure that adequate information is recorded on custody records. The FTL determines whether proper custody procedures were followed during the fieldwork.

Field Sample Coordinator–The field sample coordinator, designated by the FTL, is responsible for accepting custody of samples from the sampler(s) and properly packing and shipping the samples to the laboratory assigned to do the analyses.

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Sample Custody

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Sampler–The sampler is personally responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

Site Health and Safety Technician– The person who will use field screening instruments to monitor all field activities for VOCs and radiological contaminants and pre-shipment sample coolers. This person is a trained radiological technician who works under the guidance of Science Application International Corporation's (SAIC's) Certified Health Physicist (CHP).

4.0 Required Supplies

- Chain-of-custody record forms
- Sample labels
- Computer
- Waterproof pen
- Custody seals
- Clear tape
- Printer and paper
- Ball point ink pen

5.0 Procedures

5.1 Chain-of-Custody Record

This procedure establishes a method for maintaining custody of samples through use of a chain-of-custody record. This procedure will be followed for all samples collected.

Field Custody

1. The quantity and types of samples to be collected and the proposed sample locations are documented in the Field Sampling Plan Addendum.

2. Complete sample labels for each sample using waterproof ink.

3. Maintain personal custody of the samples (in your possession) at all times until custody is transferred to the FTL or sample coordinator for sample shipment.

Transfer of Custody and Shipment

1. Complete a chain-of-custody record for all samples (see Attachment A).To transfer the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents sample custody transfer from the sampler, often through another person, to the laboratory sample manager in the appropriate laboratory.

   - The date/time will be the same for both signatures when custody is transferred directly to another person. When samples are shipped via common carrier (e.g., Federal Express), the date/time will not be the same for both signatures. In all cases, it must be readily apparent that the person who received custody is the same person who relinquished custody to the next custodian.
   - If samples are left unattended or a person refuses to sign, this must be documented and explained on the chain-of-custody record.

   Note: The FTL or field sample coordinator will initiate the chain-of-custody record, sign, and date as the relinquisher. The individual sampler(s) must sign in the appropriate block, but does (do) not need to sign and date as a relinquisher.

2. Package samples properly for shipment and dispatch to the appropriate laboratory for analysis. Each shipment must be accompanied by a separate chain-of-custody record. If a shipment consists of multiple coolers, the original, or a copy of the chain-of-custody record shall accompany each cooler in the shipment.

3. The original record will accompany the shipment. Copies are retained by the FTL and distributed to the appropriate sample coordinator(s). Freight bills will also be retained by the FTL as part of the permanent documentation. The shipping number from the freight bill shall be recorded on the applicable chain-of-custody record and field logbook (in accordance with SSFL SOP 8).

Completing Chain-of-Custody Record

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Scribe generates a COC that shall include the following information:

1. Site name, CDM Smith contact name and phone number, COC number.
2. Name, phone number and address of the laboratory where the samples are being shipped.
3. Date shipped, courier's name, and airbill number (if applicable).
4. Sample ID number.
5. Sample date and military time.
6. Matrix and preservative.
7. Type and Number of Containers.
8. Turnaround times.
9. Analyses requested.
10. List any special instructions. Also, note which samples may have high PID or RAD concentrations as advanced notice for the laboratory.
11. Sign the COC record in the space provided, including the date and time relinquished.
12. The sampler must sign each original COC.

Review the form to ensure that all information is completed and that all entries are correct.

5.2 Sample Labels

Sample labels will be used for all samples collected at the SSFL site.

1. Complete one label with the following information for each sample container collected. For Encore Samplers, the label will be placed on the zip-top bag that contains all Encores for one sample:

   - sample identification number.
   - Date (i.e., month, day, and year of collection).
   - Time (i.e., military) of sample collection.
   - Mark to indicate soil or water sample.
   - Sampler will place their initials in the space provided.
   - List preservative type.

List or mark the "Analyses" for which the sample is to be analyzed.

2. Place adhesive labels directly on the sample containers so that the label is completely below the lid of the container. Place clear tape over the label to protect from moisture.

Note: The EnCore sampler is very small; therefore, the sample label is placed on the zip-top bag that contains the samplers.

3. Double-check that the information recorded on the sample label is consistent with the information recorded on the chain-of-custody record.

5.3 Custody Seals

Two custody seals must be placed on opposite corners of all shipping containers (e.g., cooler) before shipment. The seals shall be signed and dated by the shipper.

5.4 Sample Shipping

SSFL SOP 11 defines the requirements for packaging and shipping environmental samples. Following packing, all coolers must be screened for radiation by the Site Health and Safety Technician (SSFL SOP 7).

6.0 Restrictions/Limitations

There are no identified restrictions/limitations.

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7.0 References

U. S. Environmental Protection Agency. Revised March 1992 or current revision. *National Enforcement Investigations Center, Multi-Media Investigation Manual*, EPA-330/9-89-003-R. p.85.

_____. 2006-2011. Scribe Manuals. http://www.ertsupport.org/scribe_home.htm and http://www.epaosc.org/scribe

_____. 2011 or current revision. *Sampler's Guide, Contract Laboratory Program Guidance for Field Samplers*, EPA-540-R-09-03. January.

8.0 Attachments

Attachment A – Example Chain of Custody Form

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Sample Custody

SSFL SOP 10
Revision: 1
Date: November 2012

Attachment A
Example Chain of Custody Form

SSFL Phase 3 Chain of Custody

CDM Smith
DateShipped:
CarrierName:
AirbillNo:

Contact Name:
Contact Phone:

COC No:
Cooler #:
Lab:
Lab Phone:
Lab Address

Sample	Date/ Time	Matrix	Preserv.	Type/No of Containers	Turn Around Time	Metals 6010 and 6020	Mercury 7471 (Soil)	Mercury 7470 (Water)	Fluoride 300.0/9056	SVOC 8270	TIC 8270	PAHs 8270 SIM	1,4 Dioxane 8270 SIM	Dioxins 1613	PCB's/PCTs 8082	Perchlorate 314.0/331	Perchlorate Confirm 6850/6860	pH 9045 (Soil)	pH 9040 (Water)	Hex Cr 7196/7199	Herbicides 8151	Pesticides 8081	VOCs 8260	1,4 Dioxane 8260 SIM	TPH-GRO 8015	TPH-DRO 8015	Glycols 8015	Alcohols 8015	Terphenyls 8015	Nitrates 300.0/9056	Energetics 8330	Cyanide 9012	Formaldehyde 8315	NDMA 1625	Organotin	Methyl Mercury 1630	Other Analysis/Notes

Special Instructions:	Sampler:

Relinquished by	Date	Time	Received by	Date	Time	Relinquished by	Date	Time	Received by	Date	Time

COC Rev 2 COC: , Page1 of1

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Packaging and Shipping Environmental Samples

SSFL SOP 11
Revision: 1
Date: December 2012

Prepared: D. Lange **Technical Review:** C. Zakowski

QA Review: K. Zilis **Approved and Issued:** 12/17/2012
Signature/Date

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to outline the requirements for the packaging and shipment of environmental samples for the Santa Susana Field Laboratory (SSFL) site. Additionally, Sections 2.0 and 3.0 outline requirements for the packaging and shipping of regulated environmental samples under the Department of Transportation (DOT) Hazardous Materials Regulations, the International Air Transportation Association (IATA), and International Civil Aviation Organization (ICAO) Dangerous Goods Regulations for shipment by air and apply only to domestic shipments. This SOP does not cover the requirements for packaging and shipment of equipment (including data or bulk chemicals) that are regulated under the DOT, IATA, and ICAO. However, packaging and shipment of hazardous material and radioactive samples is not expected.

1.1 Packaging and Shipping of All Samples

This SOP applies to the packaging and shipping of all environmental samples. Samples displaying radioactivity above background concentrations will not be collected or shipped.

Note: This SOP does not address shipment of hazardous or radioactive materials. Do not ship a hazardous or radioactive material unless you have received training that meets the requirements of the Department of Energy (DOE), The Boeing Company (Boeing), CDM Smith, and the DOT.

2.0 Background

2.1 Definitions

Environmental Sample - An aliquot of sample representative of the site. This definition applies only to environmental samples that contain less than reportable quantities for any foreseeable hazardous constituents according to DOT regulations promulgated in 49 CFR - Part 172.101 Appendix A.

Custody Seal - A custody seal is a narrow adhesive-backed seal that is applied to individual sample containers and/or the container (i.e., cooler) before offsite shipment. Custody seals are used to demonstrate that sample integrity has not been compromised during transportation from the field to the analytical laboratory.

Inside Container - The container, normally made of glass or plastic, that actually contacts the shipped material. Its purpose is to keep the sample from mixing with the ambient environment.

Outside Container - The container, normally made of metal or plastic, that the transporter contacts. Its purpose is to protect the inside containers.

Secondary Containment - The outside container provides secondary containment if the inside container breaks (i.e., plastic over packaging if liquid sample is collected in glass).

Excepted Quantity - Excepted quantities are limits to the mass or volume of a hazardous material below which DOT, IATA, ICAO regulations do not apply. The excepted quantity limits are very low. Most regulated shipments will be made under limited quantity.

Limited Quantity - Limited quantity is the amount of a hazardous material exempted from DOT labeling or packaging requirements in 49 CFR. Authorized exemptions are noted under column 8A in the Hazardous Materials Table in 49 CFR 172.101.

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Qualified Shipper - A qualified shipper is a person who has been adequately trained to perform the functions of shipping hazardous materials.

2.2 Associated Procedures

- SSFL SOP 10, *Sample Custody*

2.3 Discussion

Proper packaging and shipping is necessary to ensure the protection of the integrity of environmental samples shipped for analysis. These shipments are potentially subject to regulations published by DOT. Failure to abide by these rules places both CDM Smith and the individual employee at risk of serious fines. The analytical holding times for the samples must not be exceeded. If necessary, the samples shall be packed in time to be shipped for overnight delivery or for pick-up by the laboratory courier. Make arrangements with the laboratory before sending samples for weekend delivery.

3.0 General Responsibilities

Field Team Leader–The field team leader (FTL) is responsible for:

- Ensuring that field personnel package and ship samples in accordance with this SOP.
- Ensuring samples are shipped such that holding times can be met by the laboratory.
- Ensuring normal samples collected and QC samples are documented on the Chain of Custody (CoC).

Site Health and Safety Technician–The person who will use field screening instruments to monitor all field activities for VOCs and radiological contaminants and pre-shipment sample coolers. This person is a trained radiological technician who works under the guidance of Science Application International Corporation's (SAIC's) Certified Health Physicist (CHP).

4.0 Required Equipment

The following equipment will be needed in the field trailer to conduct sample packing and shipping:

- Site-specific plans (e.g., Field Sampling Plan [FSP] Addendum, health and safety plan)
- Insulated coolers
- Heavy-duty plastic bags
- Plastic zip-top bags, small and large
- Clear tape
- Duct tape
- Nylon reinforced strapping tape
- Rubber bands (optional)
- Bubble wrap (optional)
- Ice in bags
- Custody seals
- Chain-of-custody record
- This End Up and directional arrow labels
- Overnight courier airbills

5.0 Procedures

5.1 Packaging Environmental Samples

Preservatives in samples are not anticipated to meet threshold criteria to be classified as hazardous materials for shipping purposes. The following steps must be followed when packing sample bottles and jars for shipment:

1. Verify the samples undergoing shipment meet the definition of "environmental sample" and are not a hazardous material as defined by DOT. Professional judgment and/or consultation with qualified persons such as the appropriate health and safety coordinator or the health and safety manager shall be observed.

2. Select a sturdy cooler in good repair. Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler. Line the cooler with a large heavy-duty plastic bag.

3. Be sure the caps on all bottles are tight (will not leak); check to see that labels and chain-of-custody records are completed properly (SSFL SOP 10).

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4. Place all bottles in separate and appropriately sized plastic zip-top bags and close the bags. Up to three VOA vials may be packed in one bag. Binding the vials together with a rubber band on the outside of the bag, or separating them so that they do not contact each other, will reduce the risk of breakage. Bottles may be wrapped in bubble wrap or placed into foam bottle holders.

Note: Trip blanks must be included in coolers containing VOA samples.

5. Place bubble wrap in the bottom of an empty cooler followed by a large plastic bag, and place the sample containers in the bag with sufficient space to allow for the addition of packing material between any glass containers. It is preferable to place glass sample bottles and jars into the cooler vertically. Glass containers are less likely to break when packed vertically rather than horizontally. The containers may alternatively be placed into foam or cardboard holders that fit within the coolers.

6. While placing sample containers into the cooler, conduct an inventory of the contents of the shipping cooler against the chain-of-custody record.

7. Put ice in large plastic zip-top bags (double bagging the zip-tops is preferred) and properly seal. Place the ice bags on top of and/or between the samples. Several bags of ice are required (dependant on outdoor temperature, staging time, etc.) to maintain the cooler temperature at approximately 4° Celsius (C) ± 2˚ C . Fill all remaining space between the bottles or cans with packing material. Securely fasten the top of the large plastic bag with fiber or duct tape or a zip tie.

8. Print copies of the electronic CoC form. Place one copy of the completed CoC record for the laboratory into a plastic zip-top bag, seal the bag, and tape the bag to the inner side of the cooler lid. Retain a second copy of the CoC for sample management records. Close the cooler lid.

9. The cooler lid shall be secured with nylon reinforced strapping tape by wrapping each end of the cooler a minimum of two times. Attach a completed chain-of-custody seal across the opening of the cooler on opposite sides. The custody seals shall be affixed to the cooler with half of the seal on the strapping tape so that the cooler cannot be opened without breaking the seal. Complete two more wraps around with fiber tape and place clear tape over the custody seals.

10. The shipping container lid must be marked **"THIS END UP"** and arrow labels that indicate the proper upward position of the container shall be affixed to the cooler. Labels used in the shipment of hazardous materials (such as Cargo Only Air Craft, Flammable Solids, etc.) are not permitted on the outside of containers used to transport environmental samples and shall not be used. The name and address of the laboratory is included on the shipping label (i.e., overnight delivery service label).

11. Screen the cooler with the radiation meter before shipment and document that a background level (at most) exists. The cooler will be surveyed by the RAD Technician to ensure that Radiation flux on exterior surfaces does not exceed 0.5 mrem/hr on all sides. This survey will be documented and the results reviewed by the qualified shipper, as needed.

5.2 Packaging of Limited-Quantity Radioactive Samples

Samples containing radioactivity above background will be handled in accordance with DOT shipment regulations and the requirements of the analytical laboratory receiving the samples. Per DOT shipment regulations, packages cannot exceed 200 millirem per hour and/or 2,200 disintegrations per minute as measured at any point on the package surface. Samples with exceedence of radiological screening levels (per the health and safety plan or SSFL SOP 7) will be set aside and the DOE, California Department of Toxic Substance Control (DTSC), and Boeing will be contacted. Screening limits are 30 millirem per hour and 200 disintegrations per minute.

6.0 Restrictions/Limitations

This SOP addresses the packing and shipping of environmental samples exhibiting typical radioactivity for SSFL (less than 30 millirem per hour for gamma emitters and 200 disintegrations per minute for alpha/beta emitters). Being a site that has a history of radioactive occurrences, the sample locations, samples, and coolers will be screened for radioactivity. However, CDM Smith will not handle, package, or ship samples with radioactivity that exceeds DOT regulations or the requirements of

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the receiving laboratory. If radioactivity above these levels is detected, packing and shipping work will be temporarily suspended and DOE, DTSC, and Boeing will be contacted for further direction. The cooler or samples will be set aside, and work with those samples will not resume until approved for shipment by DOE. Any effort beyond stop work will require modified SOPs.

7.0 References

U. S. Environmental Protection Agency. (EPA). 2007 or current revision. *Sampler's Guide, Contract Laboratory Program, Guidance for Field Samplers*, EPA-540-R-07-06.

Title 49 Code of Federal Regulations, Department of Transportation. 2005 or current revision. *Hazardous Materials Table, Special Provisions, Hazardous, Materials Communications, Emergency Response Information, and Training Requirements*, 49 CFR 172.

Title 49 Code of Federal Regulations, Department of Transportation. 2005 or current revision. *Shippers General Requirements for Shipments and Packaging*, 49 CFR 173.

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Field Equipment Decontamination

SSFL SOP 12
Revision: 1
Date: November 2012

Prepared: R. Kaspzyk **Technical Review:** C. Werden

QA Review: J. Oxford **Approved and Issued:** 11/26/2012
Signature/Date

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to describe the general procedures required for decontamination of non-disposable field equipment for the Santa Susana Field laboratory (SSFL) site. Given the history of radioactive material usage at SSFL, screening for radioactive materials will occur with all field operations. Decontamination of field equipment is necessary to ensure acceptable quality of samples by preventing cross-contamination. Further, decontamination reduces health hazards and prevents the spread of contaminants off site.

2.0 Background

Decontamination of equipment will occur before sampling begins and between each sample collection (for sampling equipment). All decontamination water will be collected for future disposal.

2.1 Definitions

ASTM Type II Water – Reagent grade water defined by American Society for Testing and Materials (ASTM) that is used in the final rinse of surfaces of contaminated equipment.

Clean – Free of contamination and when decontamination has been completed in accordance with this SOP.

Cross-Contamination – The transfer of contaminants through equipment or personnel from the contamination source to less contaminated or non-contaminated samples or areas.

Decontamination – The process of rinsing or otherwise cleaning the surfaces of equipment to rid them of contaminants and to minimize the potential for cross-contamination of samples or exposure of personnel.

Material Safety Data Sheets – These documents discuss the proper storage and physical and toxicological characteristics of a particular substance used during decontamination. These documents, generally included in site health and safety plans, shall be kept on site at all times during field operations.

Potable Water – Potable water is provided by local city sources and is safe for consumption. Chemical analysis of the water source will not be required before it is used.

Site Health and Safety Technician–The person who will use field screening instruments to monitor all field activities for VOCs and radiological contaminants and pre-shipment sample coolers. This person is a trained radiological technician who works under the guidance of Science Application International Corporation's (SAIC's) Certified Health Physicist (CHP).

Sampling Equipment – Equipment that comes into direct contact with the sample media.

Soap – Low-sudsing, non-phosphate detergent such as Liquinox™.

2.2 Associated Procedures

- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology Sampling*
- SSFL SOP 5, *Backhoe Trenching/Test Pits for Sample Collection*

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- SSFL SOP 6, *Field Measurement of Total Organic Vapors*
- SSFL SOP 7, *Field Measurement of Residual Radiation*
- SSFL SOP 13, *Guide to Handling Investigation-Derived Waste*

3.0 Responsibilities

Field Team Leader (FTL)-ensures that field personnel are trained in the performance of this procedure and that decontamination is conducted in accordance with this SOP. The FTL may also be required to collect and document rinsate samples (also known as equipment blanks) to provide quantitative verification that these procedures have been correctly implemented.

Field Team Member-performs decontamination of field sampling equipment and/or or oversees subcontractors performing decontamination activities. Ensures the procedures are followed, equipment is clean, and collects field equipment rinseate blanks.

4.0 Required Equipment

- Stiff-bristle scrub brushes
- Plastic buckets and troughs
- Portable hot-water/steam, high pressure spray cleaners
- Soap
- Nalgene or Teflon sprayers or wash bottles or 2- to 5-gallon, manual-pump sprayer (pump sprayer material must be compatible with the solution used)
- Plastic sheeting, plastic bags, and/or aluminum foil to keep decontaminated equipment clean between uses
- Disposable wipes, rags, or paper towels
- Potable water
- ASTM Type II water
- Trough or collection pool to contain wash waters during decontamination
- Sheet plastic to place beneath trough to contain any splash water
- Gloves, safety glasses, and other protective clothing as specified in the health and safety plan
- Tools for equipment assembly and disassembly (as required)
- 55-gallon drums for temporary storage of decontamination water
- Drum labels
- Pallets for drums holding decontamination water
- Pump to transfer water to drums (as needed)

5.0 Procedures

Decontaminate all reusable equipment (non-dedicated) used to collect and/or handle samples before coming into contact with any sampled media or personnel using the equipment. Screen all used equipment for radioactivity before transport to the decontamination area (SSFL SOP 7). Decontaminate equipment at portable decontamination stations set up at the sampling location. Transport equipment to and from the decontamination station in a manner to prevent cross-contamination of equipment and/or area. Take precautions such as enclosing large equipment (rods) in plastic wrap while being transported .

Construct the decontamination area so that contaminated water is either collected directly into appropriate containers (5-gallon buckets or steel wash tubs) suitable for collecting the decontamination water. If needed construct small soil berm or depression lined with plastic to collect any overspray or splash. Transfer water from the collection pool and containment area into 55-gallon drums for temporary storage. Stage decontamination water until sampling results or waste characterization results are obtained and evaluated and the proper disposition of the waste is determined (SSFL SOP 13).

Decontaminate all items that come into contact with potentially contaminated media before use and between sampling and/or drilling locations. If decontaminated items are not immediately used, cover them with either clean plastic or aluminum foil depending on the size of the item. Decontamination procedures for equipment are as follows:

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Field Equipment Decontamination

SSFL SOP 12
Revision: 1
Date: November 2012

General Guidelines

- Potable and ASTM Type II water will be free of all contaminants of concern.
- Decontaminated equipment will be allowed to air dry before being used.
- Equipment type, date, time, and method of decontamination along with associated field quality assurance sampling shall be recorded in the appropriate logbook.
- Gloves, boots, safety vest, safety glasses, and any other personnel protective clothing and equipment shall be used as specified in the health and safety plan.

5.1 Heavy Equipment Decontamination

The following steps will be used when decontaminating heavy equipment (i.e., backhoes):

1. Establish a decontamination area (e.g., large troughs or plastic sheeting with temporary wood bermed sides) that is large enough to fully contain the equipment to be cleaned. All decontamination areas must be upwind of the area under investigation.

2. Screen the backhoe bucket and arm for radioactivity. If measured above background, take measures to contain decontamination water separately from non-radioactive-impacted water.

3. With the heavy equipment in place, spray areas (e.g., bucket of the backhoe) exposed to contaminated media using a hand-handle sprayer. Be sure to spray down all surfaces that contact soil.

4. Use brushes, soap, and potable water to remove dirt whenever necessary.

5. Remove equipment from the decontamination pool and allow it to air dry before returning it to the work site.

6. After decontamination activities are completed, collect all contaminated wastewater, plastic sheeting, and disposable gloves, boots, and clothing in separate containers or receptacles (i.e., solids and liquids). A decontamination area may be used for multiple day/weeks provided the containment integrity is maintained. All receptacles containing contaminated items must be properly labeled for disposal. Liquids must be separated from solids and drummed.

5.2 Downhole Equipment Decontamination

Downhole equipment includes rods, stems, etc. Follow these steps when decontaminating this equipment:

1. Set up a centralized decontamination area (e.g., large trough or plastic bermed area), if possible. This area shall be set up to collect contaminated rinse waters and to minimize the spread of airborne spray.

2. Set up a “clean” area upwind of the decontamination area to receive cleaned equipment for air-drying. At a minimum, clean plastic sheeting must be used to cover tables or other surfaces on which decontaminated equipment is to be placed. All decontamination areas shall be upwind of any areas under investigation.

3. Screen all equipment for radioactivity before decontamination. If measured above background, take measures to contain decontamination water separately from non-radioactive-impacted water.

4. Place the object in a 5-gallon bucket or tub for detergent wash. If needed, longer equipment may be placed on aluminum foil or plastic-covered wooden sawhorses or other supports. The objects to be cleaned shall be at least 2 feet above the ground to avoid splash back when decontaminating.

5. Using soap and potable water wash the contaminated equipment. When using hand-held sprayers aim nozzle downward to avoid spraying outside the decontamination area. Be sure to spray inside corners and gaps especially well. Use a brush, if necessary, to dislodge dirt.

6. Move the equipment to a second bucket and rinse the equipment using clean, potable water.

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7. Using a suitable sprayer, conduct a final rinse of the equipment thoroughly with ASTM Type II water.

8. Remove the equipment from the decontamination area and place in a clean area upwind to air dry.

9. After decontamination activities are completed, collect all contaminated wastewaters, plastic sheeting, and disposable gloves, boots, and clothing in separate containers or receptacles. All receptacles containing contaminated items must be properly labeled for disposal. Liquids must be separated from solids and drummed. Any radioactive decontamination water must be contained in separate drums.

5.3 Sampling Equipment Decontamination

Follow these steps when decontaminating sampling equipment:

1. Set up a decontamination line (e.g., buckets or trough). The decontamination line shall progress from "dirty" to "clean." A clean area shall be established upwind of the decontamination wash/rinse activities to dry the equipment. At a minimum, clean plastic sheeting must be used to cover the tables or other surfaces that the decontaminated equipment is placed for drying.

2. Disassemble any items that may trap contaminants internally. Do not reassemble the items until decontamination and air drying are complete.

3. Wash the items with potable water and soap using a stiff brush as necessary to remove particulate matter and surface films.

4. Thoroughly rinse the items with potable water.

5. Rinse the items thoroughly using ASTM Type II water.

6. Allow the items to air dry completely.

7. After drying, reassemble the parts as necessary and wrap the items in clean plastic wrap, place in plastic baggies or in aluminum foil if not used immediately.

8. After decontamination activities are completed, collect all contaminated waters, plastic sheeting, and disposable personal protective equipment. Separate solid waste from liquid investigation-derived waste. Place solid items in trash bags for municipal disposal. Liquids must be separated from solids and drummed. Any radioactive decontamination water must be contained in separate drums. Refer to site-specific plans for labeling and waste management requirements.

5.4 Waste Disposal

Refer to site-specific plans and SSFL SOP 13 for waste disposal requirements. The following are guidelines for disposing of wastes:

- All wash water, rinse water, and decontamination solutions that have come in contact with contaminated equipment are to be handled, packaged (55-gallon drums), labeled, marked, stored, and disposed of as investigation-derived waste.
- Small quantities of decontamination solutions may be allowed to evaporate to dryness.
- Unless otherwise required, plastic sheeting and disposable protective clothing may be treated as solid, nonhazardous waste and placed in trash bags for disposal.
- Waste liquids shall be sampled, analyzed for contaminants of concern in accordance with disposal regulations, and disposed of accordingly.

6.0 Restrictions/Limitations

If the field equipment is not thoroughly rinsed and allowed to completely air dry before use, volatile organic residue, which

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interferes with the analysis, may be detected in the samples. The occurrence of residual organic solvents is often dependent on the time of year sampling is conducted. In the summer, volatilization is rapid, and in the winter, volatilization is slow.

7.0 References

American Society for Testing and Materials (ASTM). 2002. *Standard Practice for Decontamination of Field Equipment at Nonradioactive Waste Sites*, ASTM D5088-02. January 10.

U. S. Environmental Protection Agency. 1987. *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001.1.

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Guide to Handling Investigation-Derived Waste

SSFL SOP 13
Revision: 1
Date: November 2012

Prepared: R. Kaspzyk **Technical Review:** C. Werden

QA Review: J. Oxford **Approved and Issued:** 11/26/2012
Signature/Date

1.0 Objective

This technical standard operating procedure (SOP) presents guidance for the management of investigation-derived waste (IDW) generated at the Santa Susana Field Laboratory (SSFL) site during soil sampling, trenching, and equipment decontamination activities. The primary objectives for managing IDW during field activities include:

- Leaving the site in no worse condition than existed before field activities
- Removing wastes that pose an immediate threat to human health or the environment
- Segregating radiological wastes above background or "permissible" concentrations
- Complying with federal, state, local, regulations
- Minimizing the quantity of IDW

2.0 Background

2.1 Definitions

Hazardous Waste - Discarded material that is regulated listed waste, or waste that exhibits ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.3 or state regulations.

Investigation-Derived Wastes - Discarded materials resulting from field activities such as sampling, surveying, drilling, excavation, and decontamination processes that, in present form, possess no inherent value or additional usefulness without treatment. Wastes will be personal protective equipment, (e.g., nitrile gloves, paper towels, polyethylene sheeting) and decontamination fluids that may be classified as hazardous or nonhazardous.

Mixed Waste - Any material that has been classified as both hazardous and radioactive.

Radioactive Wastes - Discarded materials that are contaminated with radioactive constituents with specific activities in concentrations greater than the latest regulatory criteria (i.e., 10 CFR 20).

Treatment, Storage, and Disposal Facility (TSDF) - Permitted facilities that accept hazardous waste shipments for further treatment, storage, and/or disposal. These facilities must be permitted by the U.S. Environmental Protection Agency (EPA) and appropriate state and local agencies.

2.2 Discussion

Field investigation activities result in the generation of waste materials that may be characterized as hazardous or radioactive. IDWs may include solutions from decontaminating sampling equipment; and other wastes or supplies used in sampling and testing potentially hazardous or radiological contaminated material. Personal protective equipment (PPE) and other solid waste (paper towels, plastic sheeting, etc) are not considered IDW. DPT cuttings, excess sample spoils, and excavated soil will be returned to the borehole/excavation and are not considered IDW.

3.0 General Responsibilities

Field Team Leader-The field team leader (FTL) is responsible for ensuring that field personnel conduct field activities in accordance with this SOP and the Field Sampling Plan (FSP) Addendum.

Field Team Members-Field team members are responsible for implementing this SOP and communicating any unusual or unplanned condition to the FTL's attention.

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Site Health and Safety Technician–The person who will use field screening instruments to monitor all field activities for VOCs and radiological contaminants and pre-shipment sample coolers. This person is a trained radiological technician who works under the guidance of Science Application International Corporation's (SAIC's) Certified Health Physicist (CHP).

4.0 Required Equipment and Handling

4.1 IDW Containment Devices

Currently, the anticipated IDW containment device is:

- Department of Transportation (DOT)-approved 55-gallon steel containers (drums)

4.2 IDW Container Labeling

An "IDW Container" label shall be applied to each drum using indelible marking. Labeling or marking requirements for IDW are as detailed below.

- The Site Health and Safety Technician will screen all containers for radioactivity using hand-held field instruments.
- Include the following information on labels and markings: project name, generation date, location of waste origin, container identification number, sample number (if applicable), and contents (i.e., decontamination water).
- Apply each label or marking to the upper one-third of the container at least twice, on opposite sides.
- Position labels or markings on a smooth part of the container. The label must not be affixed across container bungs, seams, ridges, or dents.
- Use weather-resistive material for labels and markings and permanent markers or paint pens capable of enduring the expected weather conditions. If markings are used, the color must be easily distinguishable from the container color.
- Secure labels in a manner to ensure that they remain affixed to the container.

Labeling or marking requirements for hazardous (or radioactive) IDW expected to be transported offsite must be in accordance with the requirements of 49 CFR 172 (not anticipated for this work). Wastes determined to be hazardous or radioactive will be staged onsite until disposal options are determined by Department of Energy (DOE) or The Boeing Company (Boeing). Boeing will notify the California Department of Toxic Substances Control of disposal in accordance with Boeing's RCRA permit. Contact information is provided in the health and safety plan.

4.3 IDW Container Movement

Predetermine staging areas for IDW containers in accordance with SSFL requirements. Determine the methods and personnel required to safely transport IDW containers to the staging area before field mobilization. Handling and transport equipment will be consistent with the associated weight for both lifting and transporting. Transportation of IDW containers offsite via a public roadway is prohibited unless 49 CFR 172 requirements are met.

Wastes determined to be hazardous or radioactive will be handled as directed by DOE or Boeing and segregated from standard IDW and solid wastes.

4.4 IDW Container Storage

Stage containerized IDW awaiting results of chemical analysis at a pre-determined location on the SSFL site. Store containers such that the labels can be easily read. Provide a secondary/spill container for liquid IDW storage (e.g., steel drums shall not be stored in direct contact with the ground).

5.0 Procedures

All liquid IDW generated at the site will be disposed offsite. The field screening and chemical analyses will determine the ultimate disposition of the waste. Formal plans for the management of IDW will be determined by CDM Smith and submitted to DOE, Boeing, and DTSC for approval. Interim management of IDW is discussed below.

5.1 Collection for Offsite Disposal

Radiological screening and laboratory analysis are required before sending any IDW to an offsite TSDF or to a publicly owned treatment works (POTW). Manifests are required to accompany any IDW determined to be hazardous, and DOE

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will direct the handling of this material. Arrange with DOE and/or Boeing who are responsible for the site and signing as generator on any waste profile and all manifests or bill of ladings; it is CDM Smith's policy not to take ownership of the waste, but may sign waste profiles or manifests on behalf of DOE or Boeing, as an authorized contractor. Use permitted TSDFs and transporters for the respective wastes. Non-bulk containers (e.g., drums) must have a DOT-approved label affixed to the container and all required associated placard stickers before leaving SSFL for an offsite TSDF. Include information as required in 49 CFR 172.

5.1.1 Aqueous Liquids

Store used decontamination fluids in appropriate containers (e.g., 55-gallon drums) at a pre-designated staging area at SSFL. Prior to being disposed offsite by a disposal vendor, ship a sample of the fluids for laboratory analysis.

5.2.2 Disposable PPE and Other Solid Waste

Dispose of personal protective equipment and other solid waste (paper towels, plastic, etc.) offsite as solid waste. After screening for radioactivity, these wastes may be contained in standard plastic trash bags and placed in trash cans.

6.0 Restrictions/Limitations

The project managers will determine the most appropriate disposal option for solid waste and used decontamination fluids. Parameters to consider, especially when determining the level of protection, include the volume of IDW and the level of contaminants present in the surface and subsurface soils. Under no circumstances will IDW materials be stored in a site office or warehouse.

7.0 References

Title 49 Code of Federal Regulations, Department of Transportation. 2005 or current revision. *Hazardous Materials Table, Special Provisions, Hazardous, Materials Communications, Emergency Response Information, and Training Requirements*, 49 CFR 172.

U. S. Environmental Protection Agency (EPA).1990. *Low-Level Mixed Waste: A RCRA Perspective for NRC Licensees*, EPA/530-SW-90-057. August

_____. January 1992. *Guide to Management of Investigation-Derived Wastes*, 9345.3-03FS.

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Photographic Documentation of Field Activities

SSFL SOP 15
Revision: 0
Date: April 2012

Prepared: A. Herrington **Technical Review:** C. Werden

QA Review: J. Oxford **Approved and Issued:** 4/6/2012
Signature/Date

1.0 Objective

The purpose of this technical standard operating procedure (SOP) is to provide standard guidelines and methods for photographic documentation. All photography should be digital – camera and/or video – and document field activities and site features (geologic formations, core sections, lithologic samples, general site layout, etc.). This SOP is intended for circumstances when formal photographic documentation is required.

All photography at SSFL is highly restricted. The use of cameras or video equipment at the SSFL site requires a permit secured through the primary site manager – The Boeing Company (Boeing). Unpermitted photography is strictly prohibited.

2.0 Background

2.1 Definitions

Standard Reference Marker - A standard reference marker is a reference marker that is used to indicate a feature size in the photograph and is a standard length of measure, such as a ruler, meter stick, etc. In limited instances, if a ruled marker is not available or its use is not feasible, it can be a common object of known size placed within the visual field and used for scale.

2.2 Associated Procedures

- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology Sampling*
- SSFL SOP 5, *Backhoe Trenching/Test Pits for Sample Collection*
- SSFL SOP 8, *Field Data Collection Documents, Content, and Control*
- SSFL SOP 14, *Geophysical Survey*

2.3 Discussion

Photographs taken during field investigations are used as an aid in documenting and describing site features, sample collection activities, equipment used, and possible lithologic interpretation. This SOP provides basic details for taking photographs during fieldwork. The use of a photographic logbook or log form and standardized entry procedures are also outlined. In addition, all SOPS will be on hand with the field sampling team.

3.0 General Responsibilities

Field Team Leader-The field team leader (FTL) is responsible for ensuring that the format and content of photographic documentation are in accordance with this procedure. The FTL is also responsible for supporting decisions of items to be photographed - specific situations, site features, or operations that the photographer will be responsible for documenting.

Photographer-The photographer is one of the field crew. The photographer is responsible for maintaining a logbook or photographic log form per Sections 5.1 and 5.2 of this SOP.

4.0 Required Equipment

A general list of equipment that may be used:

- 35mm digital camera
- Standard reference markers

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- Logbook
- Indelible black or blue ink pen
- Extra batteries for 35mm camera
- Storage medium (disks or cards) for digital camera

5.0 Procedures

5.1 Documentation

Use a photographic log form and/or project specific logbook to log and document photographic activities. Review SSFL SOP 8.

5.2 Operation

5.2.1 General Photographic Activities in the Field

The following sections provide general guidelines that should be followed to visually document field activities and site features using digital cameras and video equipment. Listed below are general suggestions that the photographer should consider when performing activities under this SOP:

- The photographer should be prepared to make a variety of shots, from close-up to wide-angle. Many shots will be repetitive in nature or format, especially close-up site feature photographs.
- The lighting for sample and feature photography should be oriented toward a flat condition with little or no shadow. Or, a flash may be used.
- Digital cameras have multiple photographic quality settings. A camera that obtains a higher resolution (quality) has a higher number of pixels and will store less photographs per digital storage medium.

5.2.2 General Guidelines for Still Photography

Caption Information

All photographs will have a full caption on a photo log sheet. The caption should contain the following information (digital photographs should have a caption added after the photographs are downloaded):

- Date and time
- Direction (if applicable)
- Photographer
- Description of activity/item shown (e.g., name of facility/site, specific project name, project number)
- Any other relevant information

When possible, a standard reference marker should be used in all documentary visual media. While the standard reference marker will be predominantly used in close-up feature documentation, inclusion in all scenes should be considered.

Digital media should be downloaded at least once each day to a personal computer; the files should be in either “JPEG” or “TIFF” format. Files should be renamed at the time of download to correspond to the logbook. It is recommended the electronic files be copied to a compact disc for backup.

Close-Up and Feature Photography

Any close-up photographs should include a standard reference marker of appropriate size as an indication of the feature size. Feature samples, core pieces, and other lithologic media should be photographed as soon as possible after they have been removed from their *in situ* locations. This enables a more accurate record of their initial condition and color.

Site Area Photography

Site area and background photography is not allowed without prior permission of Boeing.

Panoramic

Panoramic photography is not allowed without prior permission of Boeing.

5.2.3 Photographic Documentation

Photographic activities must be documented in a photographic log or in a section of the field logbook. The photographer will be responsible for making proper entries.

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Photographic Documentation of Field Activities	SSFL SOP 15 Revision: 0 Date: April 2012

In addition to following the technical standards for logbook entry as referenced in SSFL SOP 8, the following information should be maintained in the appropriate logbook:

- Photographer name
- If required, an entry shall be made for each new roll control number assigned
- Sequential tracking number for each photograph taken (the camera-generated number may be used)
- Date and time (military time)
- Location
- A description of the activity/item photographed
- Record as much other information as possible to assist in the identification of the photographic document

5.3 Post Operation

5.3.1 Documentation

At the end of each day's photographic session, the photographer(s) will ensure that the field logbook (in accordance with SSFL SOP 8) and/or photographic log is complete.

5.3.2 Archive Procedures

- Photographs and the associated digital media will be submitted to the project files and handled according to contract records requirements. The project manager will ensure their proper distribution.
- Completed pages of the appropriate logbook will be copied weekly and submitted to the project files.

6.0 Restrictions/Limitations

This document is designed to provide a set of guidelines for the field amateur photographer to ensure that an effective and standardized program of visual documentation is maintained.

Note: Photography is restricted at SSFL; a camera permit from Boeing is required.

7.0 References

No references were used to develop this SOP.

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Control of Measurement and Test Equipment

SSFL SOP 16
Revision: 0
Date: April 2012

Prepared: R. Kaspzyk **Technical Review:** C. Zakowski

QA Review: J. Oxford **Approved and Issued:** 4/6/2012
Signature/Date

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to establish the baseline requirements, procedures, and responsibilities inherent to the control and use of all measurement and test equipment (M&TE; e.g., hand-held field monitoring equipment, global positioning system (GPS) unit) for the Santa Susana Field Laboratory (SSFL) site.

2.0 Background

2.1 Definitions

Requisitioner – The person responsible for ordering the leased or purchased equipment.

Traceability – The ability to trace the history, application, or location of an item and like items or activities by means of recorded identification.

2.2 Associated Procedures

- SSFL SOP 6, *Field Measurement of Total Organic Vapors*
- SSFL SOP 7, *Field Measurement of Residual Radiation*
- SSFL SOP 8, *Field Data Collection Documents, Content, and Control*
- Manufacturer's operating and maintenance and calibration procedures

2.3 Discussion

All M&TE used will be rented or leased from an outside vendor, or purchased. It is essential that measurements and tests resulting from the use of equipment be of the highest accountability and integrity. The equipment user should completely understand the operational instructions and comply with the specifications in the manufacturer's operations and maintenance manual and follow calibration procedures and in accordance with the Field Sampling Plan (FSP) Addendum.

3.0 Responsibilities

All staff with direct control and/or use of M&TE are responsible for being knowledgeable of and understanding and implementing the requirements contained herein. In addition, all field staff will be required to review the FSP Addendum, particularly as where the Addendum affects this SOP. It is possible that a variance from this SOP be identified as part of the Data Gap Investigation which would be described in the FSP Addendum.

The field team leader (FTL) or designee (equipment coordinator, quality assurance coordinator, etc.) is responsible for initiating and tracking the requirements contained herein.

4.0 Requirements for M&TE

- Determine and implement M&TE-related project-specific requirements.
- Follow the maintenance and calibration procedures when using M&TE.
- Obtain the maintenance and calibration procedures if they are missing or incomplete.
- Attach or include the maintenance and calibration procedures with the M&TE.
- Prepare and record maintenance and calibration in an equipment log or a field log as appropriate (Attachment A).
- Maintain M&TE records.
- Label M&TE requiring routine or scheduled calibration (when required).
- Perform calibration using the appropriate procedure and calibration standards; maintenance will be discussed with the supplier before conduct.

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- Identify and take action on nonconforming M&TE.

5.0 Procedures

5.1 Obtain the Operating and Maintenance and Calibration Documents

For leased equipment, the requisitioner will request the maintenance and calibration procedures, the latest calibration record, and the calibration standards certification be provided to CDM Smith. If this information is not delivered with the M&TE, ask the procurement division to request it from the vendor.

5.2 Prepare and Record Maintenance and Calibration Records

The FTL or designee will record the initial daily maintenance and calibration events in a field logbook. Subsequent maintenance and calibration events will be reported to the FTL and recorded at the end of the each day.

5.3 Operating, Maintaining, or Calibrating an M&TE Item

The FTL or designee and user must operate, maintain, and calibrate M&TE in accordance with the maintenance and calibration procedures. Record maintenance and calibration actions in the equipment log or field log.

5.4 Shipment

The rental equipment supplier must inspect the item to ensure that the maintenance and calibration procedures and latest calibration and standards certification records are included before shipment. If any documentation is missing or incomplete, the item should not be shipped.

The receiver (FTL or field requisitioner) will communicate all documentation requirements to the shipper. They must also inspect and confirm the requested equipment and records were provided upon receipt. If documentation is missing, immediately contact the procurement division and request that they obtain the documentation from the vendor.

5.5 Records Maintenance

The receiver must also forward the packing slip to the procurement division.

The user must:

- Forward the completed field log to the FTL and SSFL project manager for inclusion in the project files.
- Retain the most current maintenance and calibration record and calibration standards certifications with the M&TE item and forward previous versions to the FTL and project manager for inclusion in the project files.

5.6 Traceability of Calibration Standards

The FTL or designee and user must:

- Order calibration standards designated by the supplier.
- Request and obtain certifications for standards that clearly state the traceability.
- Request and obtain material safety data sheets for the standards.
- Monitor standards that are perishable and consume or dispose of them on or before the expiration date.

5.7 M&TE That Fails Calibration

The FTL or designee must:

- Immediately discontinue use of the equipment and segregate the item from other equipment. Notify the FTL and take immediate action to replace the item.
- Review the current and previous maintenance and calibration records to determine if the validity of current or previous measurement and test results could have been affected and notify the FTL of the results of the review.

5.8 Determine if Other Related Project Requirements Apply

In the event a different or unique piece of equipment is needed on short notice for site-specific activity, the FTL or designee

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will determine if other M&TE project-related requirements could apply. If M&TE-related requirements apply, obtain a copy of them and review and implement as appropriate.

6.0 Restrictions/Limitations

Calibration and maintenance for field instruments are critical to collecting reputable data. If field monitoring equipment is not working properly, it should not be used. Work will be suspended until functional monitoring equipment is available.

7.0 References

No references used to develop this SOP.

8.0 Attachments

Attachment A – Maintenance and Calibration Form

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Control of Measurement and Test Equipment

SSFL SOP 16
Revision: 0
Date: April 2012

Attachment A

CDM Smith A subsidiary of Camp Dresser & McKee Inc.

Maintenance and Calibration

Date: Time: (a.m./p.m.)			
Employee Name:		Equipment Description:	
Contract/Project:		Equipment ID No.:	
Activity: _____		Equipment Serial No.: _____	
Maintenance			
Maintenance Performed:			
Comments:			
Signature: _____		Date: _____	
Calibration/Field Check			
Calibration Standard:		Concentration of Standard:	
Lot No. of Calibration Standard:		Expiration Date of Calibration Standard:	
Pre-Calibration Reading:		Post-Calibration Reading:	
Additional Readings:		Additional Readings:	
Additional Readings:		Additional Readings:	
Pre-Field Check Reading:		Post-Field Check Reading:	
Adjustment(s):			
Calibration: □ Passed □ Failed			
Comments:			
Signature: _____		Date: _____	

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Laboratory Homogenization For Phase 3 Soil Samples

SSFL SOP 17
Revision: 1
Date: June 2012

Prepared: T. Burgesser
Technical Review: C. Werden
QA Review: K. Zilis
Approved and Issued: 6/06/12
Signature/Date

1.0 Objective

The objective of this standard operating procedure (SOP) is to define the requirements and responsibilities for homogenizing multiple sample containers into one discrete surface or subsurface soil for all non-volatile/semi-volatile analyses (and select other) analyses for samples collected from the Santa Susana Field Laboratory (SSFL) site. Physical homogenization of soil material will be performed by subcontract laboratories. Homogenization of the depth-discrete samples by CDM Smith will not be performed in the field or in the field trailer. This SOP is intended to identify the minimum requirements required of the subcontract laboratories and is not intended to replace or supersede existing laboratory specific SOP.

2.0 Background

Soil sample homogenization prior to laboratory analysis has been requested by the California Department of Toxic Substances Control (DTSC) for the SSFL Phase 3 non-volatile chemical analyses. Homogenization was previously performed for selected SSFL Chemical Soil Background Study samples collected in the summer and fall 2011. During the background study, DTSC homogenized soil samples for chemical analyses for dioxins/furans, pesticides/herbicides, and metals, not including hexavalent chromium. The DTSC has determined that homogenizing future soil samples for all inorganic and non-volatile analyses (refer to the Field Sampling Plan [FSP] Addendum) will provide greater consistency and comparability of the analytical results from future studies throughout SSFL sampling programs.

During Phase 3 sampling, surface and subsurface soil samples will be collected following SSFL SOPs 2, 3, 4, and 5 through the use of stainless steel sleeves or placement in glass sample jars. Because of the volume needed for multiple chemical analyses, multiple sleeves or glass jars may be required from each sampling location. Soil samples to be analyzed for metals (not including hexavalent chromium), PCBs, dioxins/furans, pesticides, herbicides, and perchlorate will be subject to homogenization. Soil samples for VOC, SVOCs, TPH, alcohols, glycols, and similar volatiles analyses will not be homogenized.

Homogenization of soil samples will be requested to be performed by each laboratory before analytical testing begins.

2.1 Definitions

Grab Sample - A discrete portion of sample material or an aliquot taken from a specific sample location at a given point in time.

Spoon/Scoop/Trowel - A small stainless steel, Teflon®, Teflon® -lined, or plastic utensil measuring approximately 6 inches in length with a stem-like handle (for manual operation). Samples are handled and combined collected using a scooping action.

Stainless Steel or Glass Trays, Bowls or Pans – Appropriately-sized mixing containers used in the homogenization process.
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2.2 Associated Procedures

- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology Sampling*
- SSFL SOP 5, *Backhoe Trenching/Test Pits for Sample Collection*
- SSFL SOP 10, *Sample Custody*

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- SSFL SOP 11, *Packaging and Shipping Environmental Samples*
- SSFL SOP 12, *Field Equipment Decontamination*

3.0 General Responsibilities

Field Team Leader-The field team leader (FTL) is responsible for ensuring that the Field Sample Coordinator is properly trained to manage the Phase 3 samples – identifying those sample sleeves and jars that do not require homogenization and those sample sleeves and jars that do require homogenization by the subcontract laboratory. The FTL also need to confirm that the sampling team is collecting sufficient sample volume for the homogenization measures.

Field Sample Coordinator–The sample coordinator is responsible for ensuring that all contracted laboratories follow this guidance in accordance with this procedure. In addition, all subcontract laboratories are required to have an SOP in place that describes in detail the specific laboratory procedures utilized to comply with this SOP.

Field Sampling Team-The field sampling team is responsible for collecting the proper volume of sample (refer to Table 1 in the FSP Addendum).

Laboratory Project Manager (PM)–The laboratory project manager is responsible for ensuring that all instructions regarding soil sample homogenization are followed by laboratory staff.

4.0 Required Equipment

Because homogenization of samples will occur a the subcontract laboratory, the laboratory supplies at a minimum should include:

- Laboratory logbook, bench sheet forms, other forms for documenting sample homogenization
- Indelible black or blue ink pens and markers
- Appropriate size sample containers (glass and plastic) with labels
- Stainless steel or glass trays, bowls, or pans
- Stainless steel or Teflon lined scoops/spoons/trowels
- Decontamination supplies
- Nitrile or appropriate gloves

5.0 Procedures

5.1 Laboratory Soil Homogenization/Compositing (Cone and Quarter Method)

The following steps will be performed by the analytical laboratory to create a composite soil sample for the non-volatile analyses. The laboratory will use sample quantities submitted in stainless steel sleeves or glass jars to perform this procedure.

1. Decontaminate all laboratory compositing equipment according to appropriate Laboratory SOPs.

2. Don appropriate PPE and gloves. Clean gloves must be worn for each sample composited.

3. With the top 1/3 and bottom 1/3 of sample material in the homogenization tray/bowl/pan, chop-up the sample into small chunks using a clean, stainless steel wallboard knife or other suitable implement.

4. Remove non-soil debris, including sticks and vegetation, as much as possible.

5. Scooping from the edge, form a mound in the center of the tray/bowl/pan.

6. Divide the mound into two equal piles and form each pile into a mound.

7. Divide each into two piles. (At this point there should be four piles in the tray/bowl/pan).

8. Mix the piles together that are opposite from each other into a single mound.

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9. Repeat steps 7, 8 and 9 until the sample is thoroughly homogenized (a minimum of 3 times).

10. Transfer the thoroughly mixed sample to appropriately labeled sample containers for the required analyses.

11. Analyze the samples.

5.2 Contracted Laboratory Compositing Equipment Decontamination

To clean laboratory equipment used in homogenization, remove all gross materials/stains/hardened material using a scrubbing pad or brush and rinsing the equipment with water. After scrubbing and rinsing, the laboratory should implement internal laboratory procedures/SOPs to complete cleaning and decontamination process to ensure the compositing equipment is free of potential cross contamination. At a minimum, the laboratory decontamination process must comply with the requirements of SSFL SOP 12.

6.0 Documentation

Document all compositing activities including decontamination in an appropriate logbook and/or bench sheet.

7.0 References

Lancaster Laboratories Inc. 2011 *SOP-SS-009 Homogenization and Subsampling of Solid Waste Samples from Environmental Sources*. July.

State of California Department of Toxic Substances Control (DTSC), 2012. *Homogenization of Soil Samples for Chemical Characterization, Santa Susana Field Laboratory, Ventura County, California*. February 29, 2012.

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Appendix E

Identified SOPs from Other Soil Treatability Studies

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Field Homogenization of Soil Samples

SSFL SOP ST PHY 6
Revision: 1
Date: October 2013

Prepared: K. Roberts **Technical Review:** P. Sharma

QA Review: K. Zilis **Approved and Issued:** September 18, 2013

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to define the techniques and requirements for homogenizing soil samples while in the field.

2.0 Background

The phytoremediation treatability study is one of five soil treatability studies commissioned by the US Department of Energy (DOE) as part of the process to identify a remediation technology for Area IV of the Santa Susana Field Laboratory (SSFL). This phytoremediation study will be conducted in two phases. Phase 1 will involve collecting plants and soils from the field site and analyzing them for contaminants of interest. Phase 1 will be used to identify the best candidate plant species for further phytoremediation research in Phase 2 of this study. This SOP addresses the field homogenization of soils collected during Phase 1 field sampling of root-zone soils and plant tissues.

2.1 Definitions

Cal Poly Phytoremediation Team is composed of members of California Polytechnic State University (Cal Poly) who will be participating in the phytoremediation treatability study for Area IV of SSFL. The Cal Poly Phytoremediation Team includes faculty, research associates, graduate students, and undergraduate students.

CDM Smith Team is composed of employees of CDM Smith and its subcontractors, excluding Cal Poly.

2.2 Associated Procedures

- SSFL SOP 1, *Procedures for Locating and Clearing Phase 3 Samples*
- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology (DPT) Sampling*
- SSFL SOP 6, *Field Measurement of Total Organic Vapors*
- SSFL SOP 7, *Field Measurement of Residual Radiation*
- SSFL SOP 8, *Field Data Collection Documents, Content and Control*
- SSFL SOP 9, *Lithologic Logging*
- SSFL SOP 10, *Sample Custody*
- SSFL SOP 11, *Packaging and Shipping Environmental Samples*
- SSFL SOP 12, *Field Equipment Decontamination*
- SSFL SOP 13, *Guide to Handling Investigation Derived Waste*
- SSFL SOP 15, *Photographic Documentation of Field Activities*
- SSFL SOP 16, *Control of Measurement and Test Equipment*
- SSFL SOP 17, *Laboratory Homogenization For Phase 3 Soil Samples*
- SSFL SOP ST PHY 1, *Plant Sampling and Root-Zone Soil Sampling*

3.0 General Responsibilities

CDM Smith – CDM Smith will collect soil samples, decontaminate field equipment, and homogenize the soil samples.

University Phytoremediation Team – The University Phytoremediation Team will be responsible for identifying field sampling locations.

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Field Homogenization of Soil Samples	SSFL SOP ST PHY 6 Revision: 1 Date: October 2013

4.0 Required Equipment

Samples for homogenization of soil samples in the field will include:

- Logbook for documenting sample homogenization
- Indelible black or blue ink pens and markers
- Stainless steel bowls (2-gallon minimum)
- Stainless steel trowel/spoon
- Decontamination supplies
- Latex, nitrile or appropriate gloves

5.0 Soil Sample Homogenization Procedures in the Field

The following procedures are required for homogenizing soil samples in the field:

1. Prior to the start of and following homogenization, decontaminate all homogenization equipment per SSFL SOP 12, Field Equipment Decontamination.
2. Identify the soil sample location and collect the soil sample per SSFL SOP ST PHY 1, Plant Sampling and Root-Zone Soil Sampling. SSFL SOP 6, Field Measurement of Total Organic Vapors and SSFL SOP 7, Field Measurement of Residual Radiation will be followed for field screening purposes.
3. Place the soil sample into a stainless steel bowl and shape the soil sample into a single pile in the bowl.
4. Divide the pile in the bowl into two separate and equal size piles using a stainless steel trowel or spoon. Identify them mentally as pile 1 and pile 2.
5. Divide each of the two piles in the bowl into two separate and equal size piles. This will create four approximately equal size piles. Mentally identify them as 1A, 1B, 2A, and 2B.
6. Thoroughly mix each of the opposing piles into each other: 1A with 2A and 1B with 2B. This will create two piles.
7. Combine the two mixed piles back into a single pile.
8. Repeat steps 3-7 until the soil sample is thoroughly mixed, based on visual indicators: color, moisture, distribution of grain size, etc.
9. Prepare homogenized samples for shipment per SSFL SOP 11, Packaging and Shipping of Environmental Samples

6.0 Documentation

Document all activities including decontamination in an appropriate logbook, per SSFL SOP 8, Field Logbook Content and Control. Document any deviations from this SOP and justifications for those deviations.

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Laboratory Sampling Equipment Decontamination

SSFL SOP ST PHY 7
Revision: 1
Date: October 2013

Prepared: K. Roberts
Technical Review: P. Sharma
QA Review: K. Zilis
Approved and Issued: September 18, 2013

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to describe the general procedures required for decontaminating nondisposable sampling equipment for the Santa Susana Field laboratory (SSFL) phytoremediation and bioremediation treatability studies conducted in California Polytechnic State University (Cal Poly) laboratories.

2.0 Background

The phytoremediation and bioremediation soil treatability studies are two of five soil treatability studies commissioned by the US Department of Energy (DOE) as part of the process to identify a remediation technology for Area IV of the Santa Susana Field Laboratory (SSFL). The phytoremediation and bioremediation soil treatability studies will be conducted at Cal Poly. Both studies will have laboratory activities. This SOP addresses the decontamination of sampling equipment used in these laboratory activities.

As a general rule, decontamination of laboratory sampling equipment will occur before sampling begins and between samples from different experiments. All decontamination water will be collected for future disposal.

2.1 Definitions

ASTM Type II Water – Reagent grade water defined by American Standards for Testing and Measurements (ASTM) that is used in the final rinse of surfaces of contaminated equipment.

Cal Poly Phytoremediation and Bioremediation Teams are composed of members Cal Poly who will be participating in the phytoremediation and bioremediation treatability studies for Area IV of SSFL. The Cal Poly Phytoremediation and Bioremediation Teams include faculty, research associates, graduate students, and undergraduate students.

CDM Smith Team is composed of employees of CDM Smith and its subcontractors, excluding Cal Poly.

Clean – Free of target compounds greater than or equal to the reporting limits, optimally the condition of the equipment when decontamination has been completed in accordance with this SOP.

Cross-Contamination – The transfer of contaminants through equipment or personnel from the contamination source to less contaminated or non-contaminated samples or areas.

Decontamination – The process of cleaning the surfaces of equipment in accordance with the procedures in this SOP, to rid them of contaminants and to minimize the potential for cross-contamination of samples or exposure of personnel.

Potable Water – Potable water is provided by local city sources and is safe for consumption.

Sampling Equipment – Equipment that comes into direct contact with the sample media.

Soap – Low-sudsing, non-phosphate detergent such as Liquinox™.

2.2 Associated Procedures

- SSFL SOP ST PHY 3, *Phytoremediation Microcosm Preparation and Operation*
- SSFL SOP ST PHY 4, *Use and Sampling of Sorbent Tubes for Phytovolatilization Measurement*

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- SSFL SOP ST PHY 5, *Laboratory Homogenization of Phytoremediation Treatability Plant Tissue Samples*
- SSFL SOP ST PHY 10, *Cal Poly Laboratory Data Collection, Documents, Content, and Control*
- SSFL SOP ST PHY 11, *Guide to Handling Experiment-Derived Waste*

3.0 General Responsibilities

CDM Smith Team – The CDM Smith Team will provide protocols for decontamination of laboratory sampling equipment.

University Phytoremediation Team - The University Phytoremediation and Bioremediation Teams will be responsible decontaminating all laboratory sampling equipment.

4.0 Required Equipment

The laboratory sampling equipment supplies will include:

- Stiff-bristle scrub brushes
- Soap
- Nalgene or Teflon sprayers or wash bottles or 2- to 5-gallon, manual-pump sprayer (pump sprayer material must be compatible with the solution used)
- Plastic sheeting, plastic bags, and/or aluminum foil to keep decontaminated equipment clean between uses
- Disposable wipes, rags, or paper towels
- Potable water
- ASTM Type II water
- Gloves, safety glasses, and other protective clothing as specified in the health and safety plan
- 5-gallon plastic buckets for washing of equipment and temporary storage of decontamination water until proper disposal

5.0 Procedures

Decontaminate all reusable equipment (excluding dedicated equipment) used to collect, handle, or measure samples before coming into contact with any sample media. Decontaminate all items that come into contact with potentially contaminated media before use and between experiments. If decontaminated items are not immediately used, cover them with either clean plastic or aluminum foil depending on the size of the item. General decontamination guidelines for SSFL are as follows:

General Guidelines

- Potable and ASTM Type II water will be free of all contaminants of concern.
- Decontaminated equipment will be allowed to air dry before being used.
- Equipment type, date, time, and method of decontamination shall be recorded in the appropriate logbook or bench sheets.
- Gloves, safety glasses, and any other personnel protective clothing and equipment shall be used as specified in the health and safety plan.

5.1 Sampling Equipment Decontamination

Follow these steps when decontaminating sampling equipment:

1. Set up a decontamination line (e.g., buckets or trough). The decontamination line shall progress from "dirty" to "clean" (e.g., dirty equipment enters the decontamination line, is decontaminated, and then exits the decontamination line as clean equipment). A clean area shall be established separate from the decontamination wash/rinse activities to dry the equipment. At a minimum, clean plastic sheeting must be used to cover the tables or other surfaces that the decontaminated equipment is placed for drying.

2. Inspect equipment for reusability and if it is not, dispose properly. Disassemble any items that may trap contaminants and/or particulate matter internally. Remove any disposable components from the equipment and dispose properly (i.e., tubing, filters, etc.). Do not reassemble the items until decontamination and air drying are complete.

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3. Wash the items with potable water and soap using a stiff brush as necessary to remove particulate matter and surface films.

4. Thoroughly rinse the items with potable water.

5. Rinse the items thoroughly using ASTM Type II water.

6. Allow the items to air dry completely.

7. After drying, reassemble the parts as necessary and wrap the items in clean plastic wrap or in aluminum foil.

8. After decontamination activities are completed, collect all contaminated waters, plastic sheeting, and disposable personal protective equipment. Wastes will be disposed of per SSFL SOP ST PHY 11, Guide to Handling Experiment-Derived Waste

6.0 Documentation

Document all decontamination activities per SSFL SOP ST PHY 10, Cal Poly Laboratory Data Collection, Documents, Content, and Control. Document any deviations from this SOP and justifications for those deviations.

7.0 References

American Society for Testing and Materials (ASTM). 2002. *Standard Practice for Decontamination of Field Equipment at Nonradioactive Waste Sites*, ASTM D5088-02. January 10.

U. S. Environmental Protection Agency. 1987. *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001.1.

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Bulk Soil Homogenization

SSFL SOP ST PHY 9
Revision: 1
Date: October 2013

Prepared: K. Roberts
Technical Review: P. Sharma
QA Review: K. Zilis
Approved and Issued: September 18, 2013

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to define the techniques and requirements for homogenizing Area IV bulk soils collected for use in Phase 2 of the phytoremediation soil treatability study.

2.0 Background

The phytoremediation treatability study is one of five soil treatability studies commissioned by the US Department of Energy (DOE) as part of the process to identify a remediation technology for Area IV of the Santa Susana Field Laboratory (SSFL). This phytoremediation study will be conducted in two phases. Phase 1 will involve collecting plants and soils from the field site and analyzing them for contaminants of interest. Phase 1 will be used to identify the best candidate plant species for further phytoremediation research in Phase 2 of this study. Phase 2 will involve growing plants in controlled laboratory conditions in microcosms to assess the rates and mechanisms of phytoremediation. This SOP addresses homogenization of the soils used in the Phase 2 microcosms.

2.1 Definitions

Cal Poly Phytoremediation Team is composed of members of California Polytechnic State University (Cal Poly) who will be participating in the phytoremediation treatability study for Area IV of SSFL. The Cal Poly Phytoremediation Team includes faculty, research associates, graduate students, and undergraduate students.

CDM Smith Team is composed of employees of CDM Smith and its subcontractors, excluding Cal Poly.

Round poly wading pool is a hard plastic pool with a shallow depth of typically less than 1 foot. It is commonly referred to as a "kiddie pool". Hard plastic pools will be selected that do not have paint on the interior surface of the pool.

2.2 Associated Procedures

- SSFL SOP 1, *Procedures for Locating and Clearing Phase 3 Samples*
- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 6, *Field Measurement of Total Organic Vapors*
- SSFL SOP 7, *Field Measurement of Residual Radiation*
- SSFL SOP 8, *Field Data Collection Documents, Content and Control*
- SSFL SOP 9, *Lithologic Logging*
- SSFL SOP 10, *Sample Custody*
- SSFL SOP 11, *Packaging and Shipping Environmental Samples*
- SSFL SOP 12, *Field Equipment Decontamination*
- SSFL SOP 13, *Guide to Handling Investigation Derived Waste*
- SSFL SOP 15, *Photographic Documentation of Field Activities*
- SSFL SOP 16, *Control of Measurement and Test Equipment*
- SSFL SOP 17, *Laboratory Homogenization For Phase 3 Soil Samples*
- SSFL SOP ST PHY 3, *Phytoremediation Microcosm Preparation and Operation*
- SSFL SOP ST PHY 8, *Bulk Soil Sampling*

3.0 General Responsibilities

CDM Smith Team – The CDM Smith team will collect the bulk soil samples, conduct the soil homogenization, and provide for transport of the soils to the Cal Poly facility.

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Bulk Soil Homogenization

SSFL SOP ST PHY 9
Revision: 1
Date: October 2013

Cal Poly Phytoremediation Team – The Cal Poly Phytoremediation Team will oversee the bulk soil sample collection, homogenization, and transport of soils.

4.0 Required Equipment

The sample collection supplies will include:

- Field logbook for documenting sample collection
- Indelible black or blue ink pens and markers
- Bulk soil samples
- Decontamination supplies
- Latex, nitrile or appropriate gloves
- Shovels with stainless steel blades
- 9-ft^3 or greater volume steel drum concrete mixer with electric motor
- 4-ft diameter x 6-inch depth (or larger) round poly wading pools (minimum of three)
- Plastic 5-gallon buckets with lids
- Teflon liners for 5-gallon buckets
- Labels for buckets

5.0 Procedures

5.1 Bulk soil homogenization procedures

1. Decontaminate all homogenization equipment including the inside of the concrete mixer drum, per SSFL SOP 12, Field Equipment Decontamination before sampling any location.
2. Wear proper personal protective equipment while handling all samples, sample containers, and homogenization devices.
3. Perform bulk soil homogenization, as follows in this SOP, in a location with adequate ventilation.
4. Add 5-gallons (one 5-gallon bucket) of the bulk soil to the cement mixer drum. Mix at high speed for 5 minutes.
5. Repeat step 4 until 30 gallons of soil have been added to the mixer and mixed.
6. Empty the 30 gallons of mixed soil to a decontaminated round poly wading pool.
7. Repeat steps 4 and 5 until the remainder of the bulk soil (32.5 gallons) has been added to the mixer and mixed.
8. Empty the 32.5 gallons of mixed soil to a second decontaminated round poly wading pool.
9. Separate the soil in each round poly wading pool into equal halves.
10. Using the shovel, add half of the soil from each round poly wading pool to the mixer. Mix at high speed for 5 minutes.
11. Empty the soil into a third decontaminated round poly wading pool.
12. Using the shovel, add the remaining halves of soil from each of the first two round poly wading pool to the mixer. Mix at high speed for 5 minutes.
13. Empty the soil into one of the used but empty round poly wading pools.
14. Repeat steps 10 through 14 using the three round poly wading pools and the mixer until the soil is thoroughly homogenized, as determined by visual inspection: color, moisture, distribution of grain size, etc.
15. Store the homogenized soils in Teflon-lined 5-gallon buckets for transport and until use in the microcosms (SSFL SOP ST PHY 3, Phytoremediation Microcosm Preparation and Operation)

6.0 Documentation

Document all sample collection and processing activities, per SSFL SOP 8, Field Logbook Content and Control. Document any deviations from this SOP and justifications for those deviations.

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Cal Poly Laboratory Data Collection, Documents, Content, and Control

SSFL SOP ST PHY 10
Revision: 1
Date: October 2013

Prepared: K. Roberts
Technical Review: C. Werden
QA Review: J. Oxford
Approved and Issued: September 18, 2013

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to set criteria for content entry and records maintenance of laboratory logbooks and bench sheets used for Santa Susana Field Laboratory (SSFL) phytoremediation and bioremediation soil treatability study work conducted at California Polytechnic State University (Cal Poly) facilities.

2.0 Background

The phytoremediation and bioremediation treatability studies are two of the five soil treatability studies commissioned by the US Department of Energy (DOE) as part of the process to identify a remediation technology for Area IV of SSFL. Portions of the phytoremediation and bioremediation treatability studies will be conducted at Cal Poly facilities. This SOP sets criteria for content entry and records maintenance of laboratory logbooks and bench sheets for SSFL phytoremediation and bioremediation soil treatability study tasks conducted at Cal Poly facilities.

2.1 Definitions

Bench Sheet is a single 8.5 x 11-inch form used in place of a laboratory logbook to record results from laboratory experiments. The bench sheet has entry blanks or boxes for filling in experiment information, including, but not limited to, dates, times, personnel, general observations, and other relevant information that will be recorded during an experiment (e.g., plant height).

Cal Poly Team is composed of members of Cal Poly who will be participating in the phytoremediation and bioremediation treatability studies for Area IV of SSFL. The Cal Poly Team includes faculty, research associates, graduate students, and undergraduate students.

CDM Smith Team is composed of employees of CDM Smith and its subcontractors, excluding Cal Poly.

Log Book is a hard bound book with sequentially numbered blank pages for documenting the conduct of the entire treatability study test – start to finish. The detail must be sufficient to recreate details of the test (also refer to SSFL SOP 8 – Field Logbook Content and Control).

2.2 Associated Procedures

- SSFL SOP 8, *Field Logbook Content and Control*
- SSFL SOP 15, *Photographic Documentation of Field Activities*
- SSFL SOP ST PHY 3, *Phytoremediation Microcosm Preparation and Operation*
- SSFL SOP ST PHY 4, *Use and Sampling of Sorbent Tubes for Phytovolatilization Measurement*
- SSFL SOP ST PHY 7, *Laboratory Sampling Equipment Decontamination*
- SSFL SOP ST PHY 11, *Guide to Handling Experiment-Derived Waste*
- SSFL SOP ST BIO X, *(bioremediation treatability study SOPs are currently in development)*

3.0 General Responsibilities

Cal Poly Team is responsible for (a.) entering the data into and maintaining the original hard copies of laboratory logbooks and bench data sheets during the course of the phytoremediation and bioremediation studies, (b.) electronically scanning (PDF format) the original hard copies of logbook pages and bench sheets at least weekly during the course of the treatability study, (c.) forwarding the electronic copies of the laboratory logbook and bench sheet pages to the CDM Smith

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treatability task leader after scanning, and (d.) forwarding the complete electronic copies of laboratory logbooks and bench sheets to the CDM Smith task leader at the conclusion of the phytoremediation and bioremediation treatability studies. The Cal Poly Team will also develop the format of experiment-specific bench sheets.

CDM Smith Team is responsible for filing the electronic copies of laboratory logbooks and bench sheets provided by the Cal Poly Team during the course of the phytoremediation and bioremediation studies, and maintaining (per the SSFL Records Management Plan) the electronic copies of laboratory logbooks and bench sheets after the phytoremediation and bioremediation treatability studies have been completed. The CDM Smith Team will also review the format of experiment-specific bench sheets with DOE and the California Department of Toxic Substances Control (DTSC).

4.0 Required Equipment

- Laboratory logbook(s), bound and sequentially paginated
- Experiment-specific laboratory bench sheets, dated and labeled with all applicable experiment information
- Indelible black or blue ink pen
- Electronic scanner to make Portable Document Format (PDF) color scans of laboratory bench sheets and laboratory logbook pages

5.0 Procedures

5.1 General Preparation

In addition to this SOP, the Cal Poly Team members responsible for maintaining logbooks and bench sheets must be familiar with all steps of the laboratory procedures being performed. The procedures should be consulted as necessary to obtain specific information about equipment and supplies, health and safety, experiment operation, sample collection, packaging, decontamination, and documentation. The procedures should be located in the Cal Poly facility(ies) where the experiment(s) is taking place for easy reference.

5.1 Logbook Preparation

Laboratory logbooks will be bound, with lined and consecutively numbered pages. All pages must be numbered before initial use of the logbook. Before use, a member of the Cal Poly Team will title and sequentially number each logbook, and ensure the pages are sequentially numbered and the table of contents (TOC) is set up. Record the following information on the cover of the logbook:

- Entitle the logbook “SSFL AREA IV PHYTOREMEDIATION SOIL TREATABILTY STUDY” or “SSFL AREA IV BIOREMEDIATION SOIL TREATABILTY STUDY”, as appropriate
- Laboratory logbook number
- Facility name and location
- Start date of entries
- End date of entries
- Name of CDM Smith contact and phone number(s)
- Name of Cal Poly Team contact and phone number(s)

The first few (approximately two) pages of the logbook will be reserved for a table of contents (TOC). Mark the first page with the heading “Table of Contents” and enter the following:

Table of Contents

Date/Description	Pages
(Start Date)/Reserved for TOC	1-2

The remaining pages of the TOC will also be designated as such with “Table of Contents” written on the top center of each page. The TOC should be completed as activities are completed.

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5.2 Bench Sheet Preparation

Experiment-specific bench sheets will be developed by the Cal Poly Team prior to any laboratory experiments. All bench sheet formats will be reviewed by CDM Smith, DOE, and DTSC prior to use by the Cal Poly Team.

5.3 Logbook and Bench Sheet Requirements

Documentation requirements for logbooks and bench sheets are:

- Record the following information on a daily basis:
  -Date and time (start and end)
  -Name of individual making entry
  -Names of laboratory team and other persons in laboratory
  -Description of activity being conducted, including experiment identifier (i.e., unique microcosm identification number) if appropriate
  -Level of personal protection used
  -Make, model, and serial numbers of instruments
  -Equipment calibration information (initial and ongoing date and time activity)
  -Serial/tracking numbers on documentation (e.g., carrier air bills)
- Record work, observations, quantity of materials, experiment calculations and drawings, and related information directly in the logbook or on the bench sheet. If laboratory bench sheets are used for a specific activity, this information does not need to be duplicated in the logbook. However, laboratory bench sheets used to record experiment information must be referenced in the logbook. The details should be sufficient that the experiment can be recreated via the record.
- Do not start a new logbook or bench sheet page until the previous one is full or has been marked with a single diagonal line so that additional entries cannot be made. Use both sides of each logbook page. Bench sheets should be single-sided pages.
- Do not erase or blot out any entry at any time. Indicate any deletion by a single line through the material to be deleted. Initial and date each deletion. Take care to not obliterate what was written previously.
- Do not remove any pages from the logbook or dispose of any bench sheets.
- All markings and notes will be made with indelible and water proof black or blue ink pen.
- Initial and date each page of the logbook. Sign and date the final page of entries for each day of the logbook. Sign and date each bench sheet page.
- Initial and date all changes.
- If authors change within the course of the day, the original author must insert the following:
  Above notes authored by:
  - (Sign name)
  - (Print name)
  - (Date)
- The new author must sign and print his/her name before additional entries are made.
- Draw a diagonal line through the remainder of the final logbook page at the end of the day. Draw a diagonal line through any unused entry blanks of a bench sheet page at the end of the day.
- Entries shall be preceded with the time (written in military units) of the observation. The time should be recorded frequently and at the point of events or measurements that are critical to the activity being logged.
- All measurements made and samples collected must be recorded.
- A sketch of an experiment may be warranted. All sketches made in the logbook should have descriptions of the features shown.
- Record any deviations from procedures outlined in any governing documents. Also, record the reason for any noted deviation and the name of anyone whom with modified procedures were reported to and/or discussed.
- Record any problems, downtime, or delays.
- Document any upgrade or downgrade of personal protection equipment.
- Document any visitors to the laboratory.

5.4 Electronic File Maintenance Requirements

The Cal Poly Team will electronically scan all pages of laboratory logbooks (including the cover) and laboratory bench sheets to produce a color PDF for archiving at least weekly. All logbook and bench data sheet pages must be reviewed

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and signed by another Cal Poly Team member before being scanned and copied into a PDF file. These PDF files will be sent electronically to the CDM Smith treatability task leader weekly, at a minimum. Complete PDF files of all laboratory logbooks and bench sheets will be sent electronically to the CDM Smith treatability task leader at the conclusion of the phytoremediation and bioremediation treatability studies. The CDM Smith task leader will archive these electronic copies of the laboratory logbook and laboratory bench sheets on ProjectWise, a CDM Smith data storage and organization system.

5.5 Photographs

All digital photographs will be documented on a photographic log in the logbook or on a separate form (reference in the logbook). Captions must be added to the file name after the photographs are downloaded. The caption should be a unique identifier – number or date and short description. The photographic log should contain the following information:

- Photograph sequence number
- Description of activity/item shown (e.g., SSFL and sampling activity)
- Date and time
- Direction (if applicable)
- Name of photographer

Digital photographs and the associated photograph log will be submitted to the CDM Smith treatability task leader weekly, at a minimum. The CDM Smith task lead will archive the digital photographs and the associated photograph log on ProjectWise.

5.6 Daily Review Requirements

At the conclusion of each day, the individual responsible for the logbook will ensure that all entries have been appropriately made, signed, and dated and that corrections were made properly (single lines drawn through incorrect information then initialed and dated).

6.0 Restrictions/Limitations

Laboratory logbooks and laboratory bench sheets constitute the official record of experimental work, investigations, and data collection activities. They may be used in court to indicate dates, personnel, procedures, and techniques employed during experimental activities. Entries made in these logbooks and bench sheets should be factual, clear, precise, and non-subjective. Field logbooks and bench sheets, and entries within, are not to be used for personal use.

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Guide to Handling Experiment-Derived Waste

SSFL SOP ST PHY 11
Revision: 1
Date: October 2013

Prepared: K. Roberts
Technical Review: C. Werden
QA Review: J. Oxford
Approved and Issued: September 18, 2013

1.0 Objective

This technical standard operating procedure (SOP) presents criteria for the management of experiment-derived waste (EDW) generated at California Polytechnic State University (Cal Poly) facilities during phytoremediation soil treatability experiments. The primary objectives for managing EDW are minimizing the quantity of EDW and complying with applicable regulations for EDW disposal.

2.0 Background

The phytoremediation treatability study is one of five soil treatability studies commissioned by the US Department of Energy (DOE) as part of the process to identify a remediation technology for Area IV of the Santa Susana Field Laboratory (SSFL). This phytoremediation study will be conducted in two phases. Phase 1 will involve collecting plants and soils from the field site and analyzing them for contaminants of interest. Phase 1 will be used to identify the best candidate plant species for further phytoremediation research in Phase 2 of this study. Phase 2 will involve using seeds collected from Area IV for controlled growth laboratory experiments in microcosms to determine rates of phytoremediation. This SOP addresses the handling of EDW generated by Phase 2.

EDW is material that a) is generated during the setup, operation, sampling, or decommissioning of the phytoremediation treatability Phase 2 microcosms, b) has come into physical contact with the microcosm soils, plant tissues, or vapors from the plants or soils during vapor sampling, and c) is disposable. Examples of EDW include, but are not limited to, decontamination liquids, disposable sampling equipment, and disposable sampling personal protective equipment (PPE) (e.g., nitrile gloves).

Soils and plant tissues from the phytoremediation treatability study that remain in the microcosms after the final phytoremediation treatability Phase 2 sampling event (i.e., that volume of tissues and soils not collected for chemical analyses by the contract laboratory) will be containerized and stored in a secure location at Cal Poly. Only Cal Poly researchers will have access to this location. These containerized soils and tissues will then be transported to Area IV of SSFL. The soils and tissues will remain in their containers at Area IV until full scale Area IV site remediation. At that time, these containerized soils and tissues will be treated with other contaminated Area IV soils and plant tissues. These soils and plant tissues that are returned to Area IV from Cal Poly are not considered EDW.

2.1 Definitions

Cal Poly Phytoremediation Team is composed of members of Cal Poly who will be participating in the phytoremediation treatability study for Area IV of SSFL. The Cal Poly Phytoremediation Team includes faculty, research associates, graduate students, and undergraduate students.

CDM Smith Team is composed of employees of CDM Smith and its subcontractors, excluding Cal Poly.

Experiment-Derived Wastes are discarded materials resulting from laboratory activities such as experiment operation, sampling, and decontamination processes that, in present form, possess no inherent value or additional usefulness without treatment. Wastes will be personal protective equipment, (e.g., nitrile gloves, paper towels, polyethylene sheeting) and decontamination fluids.

California Environmental Protection Agency Department of Toxic Substances Control (DTSC) – Regulating agency that will review and approve disposal plans.

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2.2 Associated Procedures

- SSFL SOP 17, *Laboratory Homogenization of Phase 3 Soil Samples*
- SSFL SOP ST PHY 3, *Phytoremediation Microcosm Preparation and Operation*
- SSFL SOP ST PHY 4, *Use and Sampling of Sorbent Tubes for Phytovolatilization Measurement*
- SSFL SOP ST PHY 5, *Laboratory Homogenization of Phytoremediation Treatability Plant Tissue Samples*
- SSFL SOP ST PHY 7, *Laboratory Sampling Equipment Decontamination*
- SSFL SOP ST PHY 10, *Cal Poly Laboratory Data Collection, Documents, Content, and Control*

3.0 General Responsibilities

Cal Poly Phytoremediation Team-This team will perform all phytoremediation laboratory experiments except for analytical chemistry. The Cal Poly Phytoremediation Team will be responsible for implementing this SOP during phytoremediation soil treatability laboratory experiments and properly containerizing and managing all EDW during the tests.

CDM Smith Team-This team will collect all soils used in phytoremediation laboratory experiments, arrange for chemical analyses of EDW prior to disposal, and arrange for proper transport and disposal of EDW from Cal Poly. The CDM Smith Team will supply the EDW containment device to Cal Poly. The CDM Smith Team will also supply containment devices for the collection of SSFL soils used in the Phase 2 phytoremediation treatability experiments at Cal Poly. The CDM Smith Team will arrange for these soils to be returned to SSFL.

4.0 Waste Container and Handling

4.1 EDW Containment Devices

The anticipated EDW containment devices are Department of Transportation (DOT)-approved 55-gallon steel containers (drums).

4.2 EDW Container Labeling

An “EDW Container” label shall be applied to each drum using indelible marking. Labeling or marking requirements for EDW are detailed below.

- Include the following information on labels and markings: project name, generation date (beginning and end dates), location of EDW origin, container identification number, sample number (if applicable), contents (i.e., decontamination water), and contact person’s name and number.
- Apply each label or marking to the upper one-third of the container at least twice, on opposite sides.
- Position labels or markings on a smooth part of the container. The label must not be affixed across container bungs, seams, ridges, or dents.
- Use weather-resistive material for labels and markings and permanent markers or paint pens. If markings are used, the color must be easily distinguishable from the container color.
- Secure labels in a manner to ensure that they remain affixed to the container.

4.3 EDW Container Movement

EDW containers shall be moved according to the following procedure:

- Determine staging areas for EDW containers. These staging areas will be secured areas with access limited to Cal Poly researchers only.
- Determine the personnel required to safely transport EDW containers to the staging areas. A minimum of two personnel will be used to move the drums. At least one of the personnel will have prior experience with moving drums.
- Determine the methods and equipment required to safely transport EDW containers to the staging areas. Handling and transport equipment will be consistent with the associated weight for both lifting and transporting a drum. A drum dolly, lift gate truck, or fork lift are potential options.
- The selected personnel will use the selected method and equipment to move the drum(s) to the staging area before experimental activities begin.

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4.4 EDW Container Storage

Stage containerized EDW at a pre-determined secure location at Cal Poly. Store containers such that the labels can be easily read. Provide a secondary/spill container for liquid EDW storage (e.g., steel drums shall not be stored in direct contact with the ground). Storage at Cal Poly should not exceed 90 days once a drum is filled.

5.0 Procedures for EDW Removal from Cal Poly

All EDW generated at Cal Poly for this study and not disposed of as solid trash (see Section 5.2 of this document) will be containerized and stored temporarily onsite until it is transported to Area IV for continued storage. Liquid and solid EDW must be stored separately. Solid EDW will be disposed of as trash. Liquid EDW will be transported from Cal Poly to Area IV. CDM Smith expects that liquid EDW will be disposed of/treated at Area IV once site-wide remediation activities have begun. Interim management of EDW is discussed below.

5.1 Aqueous EDW

All liquid materials from the experiments will be retained in drums at a pre-designated staging area at Cal Poly, as described above. All drums will be properly labeled and temporarily stored as described above. CDM Smith will coordinate the appropriate DOT-approved label(s) and all required associated placard stickers affixed to the EDW container(s). CDM Smith will also coordinate transport of the EDW-filled drums from Cal Poly to Area IV.

5.2 Disposable PPE and Other Solid EDW

Dispose of personal protective equipment and other solid waste (e.g., paper towels, plastic, etc.) offsite as solid trash. Disposable PPE and other solid EDW may be contained in standard plastic trash bags and placed in trash cans for municipal trash collection and landfill disposal.

6.0 Documentation

Document all handling and disposal activities for EDW per SSFL SOP ST PHY 10, Cal Poly Laboratory Data Collection, Documents, Content, and Control. Document any deviations from this SOP and justifications for those deviations. Transmit all EDW documentation to CDM Smith per SSFL SOP ST PHY 10, Cal Poly Laboratory Data Collection, Documents, Content, and Control.

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Appendix F

Bioremediation Treatability Study SOPs

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Bioremediation Microcosm Preparation and Operation

SSFL SOP ST BIO 1
Revision: 1
Date: February 2014

Prepared: Y. Nelson (California Polytechnic State University) / K. Roberts (CDM Smith)

Technical Review: P. Sharma

QA Review: J. Oxford

Approved and Issued: February 5, 2014

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to define the techniques and requirements for preparing and operating the microcosms used in Phase 2 of the bioremediation soil treatability study.

2.0 Background

The bioremediation soil treatability study is one of five soil treatability studies commissioned by the US Department of Energy (DOE) as part of the process to identify a remediation technology for Area IV of the Santa Susana Field Laboratory (SSFL). The bioremediation study will be conducted in two phases. Phase 1 will involve collecting samples from Area IV soils to identify contaminant degrading bacteria and fungi currently present in the soils. Phase 2 will use laboratory soil microcosms to determine the likely extents and rates of biodegradation occurring in Area IV. Phase 2 will also investigate the potential of biostimulation (addition of nutrients, surfactants, bulking agents, etc.) and/or bioaugmentation (addition of microorganisms) to increase contaminant of interest (COI) biodegradation rates and/or facilitate end-product degradation mechanisms. This SOP addresses the preparation and operation of the laboratory microcosms used in Phase 2 of the bioremediation soil treatability study.

2.1 Definitions

Cal Poly Bioremediation Team is composed of members of California Polytechnic State University (Cal Poly) who will be participating in the bioremediation soil treatability study for Area IV of SSFL. The Cal Poly Bioremediation Team includes faculty, research associates, graduate students, and undergraduate students.

CDM Smith Team is composed of employees of CDM Smith Inc. and its subcontractors, excluding Cal Poly.

2.2 Associated Procedures

- SSFL SOP 1, *Procedures for Locating and Clearing Phase 3 Samples*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology (DPT) Sampling*
- SSFL SOP 6, *Field Measurement of Total Organic Vapors*
- SSFL SOP 7, *Field Measurement of Residual Radiation*
- SSFL SOP 8, *Field Data Collection Documents, Content and Control*
- SSFL SOP 9, *Lithologic Logging*
- SSFL SOP 10, *Sample Custody*
- SSFL SOP 11, *Packaging and Shipping Environmental Samples*
- SSFL SOP 12, *Field Equipment Decontamination*
- SSFL SOP 13, *Guide to Handling Investigation Derived Waste*
- SSFL SOP 15, *Photographic Documentation of Field Activities*
- SSFL SOP 16, *Control of Measurement and Test Equipment*
- SSFL SOP 17, *Laboratory Homogenization For Phase 3 Soil Samples*
- SSFL SOP ST PHY 8, *Bulk Soil Sampling*
- SSFL SOP ST PHY 9, *Bulk Soil Homogenization*

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- SSFL SOP ST PHY 10, *Cal Poly Laboratory Data Collection, Documents, Content, and Control*
- SSFL SOP ST BIO 3, *Guide to Handling Bioremediation Treatability Experiment-Derived Waste*

3.0 General Responsibilities

CDM Smith Team will provide microcosm experiment oversight and bulk soil collection and homogenization of aerobic soil samples in the field. CDM Smith Team will also perform the field investigation to determine the presence or absence of anaerobic soils at Area IV and collect the anaerobic soil samples, if such soils are present.

Cal Poly Bioremediation Team will be responsible for the construction, operation, and sampling of the bioremediation microcosms. The Cal Poly Bioremediation Team will also homogenize anaerobic soil samples for use in the microcosms if anaerobic soils are collected from Area IV.

4.0 Required Equipment

Microcosm construction and operation requires the following materials:

- 4-liter glass jars with Teflon-lined lids
- Acid-washed graduated cylinders of various volumes (50 milliliter to 1 liter)
- 10% trace-metal grade nitric acid
- 52 kilogram (kg) of soil from sample location 5C_DG-516
- 8 kg of soil from sample location 5C_DG-755
- 8 kg of soil from sample location PUBS1044
- 8 kg of soil from the Anaerobic Sample Location (if anaerobic soils are found to be present at Area IV)
- #4 soil sieve (4.750 millimeter opening)
- Laboratory logbook and bench sheet forms
- Indelible black or blue ink pens and markers
- 4-ounce and 16-ounce glass sample containers with labels for sample shipment to the analytical laboratory
- Stainless steel trays, bowls, or pans
- Stainless steel spatula
- ½-inch stainless steel push tube soil sampler
- Nitrogen gas
- Sealed laboratory glove box
- Dry ice, for storage of anaerobic soil samples in the field and transport to Cal Poly
- Alconox
- Balance, with a sensitivity of at least 0.1 grams
- Personal Protective Equipment (PPE), including eye protection, laboratory coat, and nitrile gloves
- Laboratory fume hood
- Deionized water
- Magnetic stir plate
- Magnetic stir bar
- Phanerochaete chrysosporium (P. chrysosporium)
- Rice hulls
- Malt extract
- P. chrysosporium slant agar pieces
- Miracle-Gro
- De-oiled soya lecithin granules
- Plastic weigh boats

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5.0 Procedures

5.1 Microcosm Experiment Overview

Microcosms are controlled environments that are used in a laboratory setting to assess the impact of experimental variables on that controlled environment. The Phase 2 microcosms described in this SOP will either mimic Area IV soil moisture and oxygen levels to determine likely extents and rates of biodegradation occurring in Area IV, or investigate the potential of biostimulation (addition of nutrients, surfactants, bulking agents, etc.) and/or bioaugmentation (addition of microorganisms) to increase these COI biodegradation rates and/or facilitate end-product degradation mechanisms.

The Phase 2 microcosm experiments are designed to mimic both aerobic and anaerobic Area IV soil conditions, if anaerobic soils are present at Area IV. A one day field investigation will be conducted at locations within Area IV to test for the presence of anaerobic soils deeper than ten feet below the soil surface. This investigation will use a probe attached to a drill rig to collect soil vapor samples from in situ soils. These soil vapor samples will be analyzed to determine the oxygen content of these soils at depth. The number of locations sampled will be determined by the time required to conduct this sampling at each location. If anaerobic conditions are found, these soils will be collected for use in the anaerobic microcosms.

Aerobic soil will be collected per SSFL SOP ST PHY 8, *Bulk Soil Sampling* and homogenized per SSFL SOP ST PHY 9, *Bulk Soil Homogenization*. 52 kilograms (kg) of soil will be collected from sample location 5C_DG-516. 8 kg of soil will be collected from sample location 5C_DG-755. 8 kg of soil will be collected from sample location PUBS1044. These sample locations are identified in the bioremediation soil treatability study plan. All soil samples will be screened per the applicable SOPs contained in the "*Work Plan for Chemical Data Gap Investigation Phase 3 Soil Chemical Sampling at Area IV, Santa Susana Field Laboratory, Ventura County, California*" (March 2012).

Eight kg of soil will be collected from the anaerobic sample location, as identified by the field investigation of anaerobic soils. This soil will be collected per SSFL SOP 4*, Direct Push Technology (DPT) Sampling* or SSFL SOP 3*, Subsurface Soil Sampling with Hand Auger*. The soil samples will be both stored in the field and transported to Cal Poly in an oxygen free environment (e.g., cooler containing dry ice). The soil samples will be stored in nitrogen gas at Cal Poly until the microcosms are prepared. The anaerobic soil samples will be homogenized inside of a nitrogen-filled glovebox at Cal Poly per SSFL SOP 17, *Laboratory Homogenization For Phase 3 Soil Samples*. All soil samples will be screened per the applicable SOPs contained in the "*Work Plan for Chemical Data Gap Investigation Phase 3 Soil Chemical Sampling at Area IV, Santa Susana Field Laboratory, Ventura County, California*" (March 2012).

Each microcosm growth chamber will be a 4-liter glass jar filled with 1.4 kg of soil from Area IV and sealed with a Teflon-lined lid to provide an air-tight seal (see Figure 1). The headspace of the aerobic microcosm jars will initially be filled with ambient air prior to sealing with the lid. This headspace of ambient air will provide adequate oxygen to maintain the aerobic conditions of the soil during the course of the experiment. The headspace of the anaerobic microcosm jars will initially be filled with nitrogen while in a sealed laboratory glovebox prior to sealing with the lid. The nitrogen-filled headspace will preserve the anaerobic conditions of the soil. The headspace of the anaerobic microcosm jars will be re-filled with nitrogen following sampling events. Microcosms will be operated in the Environmental Protection Engineering Laboratory of Cal Poly (Cal Poly Building 13, Room 114). Access to this laboratory is limited to Cal Poly researchers.

All liquids, soil amendments, and soils used in the bioremediation study will be sent to a contract laboratory and tested for the analytes in Table 1. Samples will be shipped to the contract laboratory per SSFL SOP 11, *Packaging and Shipping Environmental Samples*.

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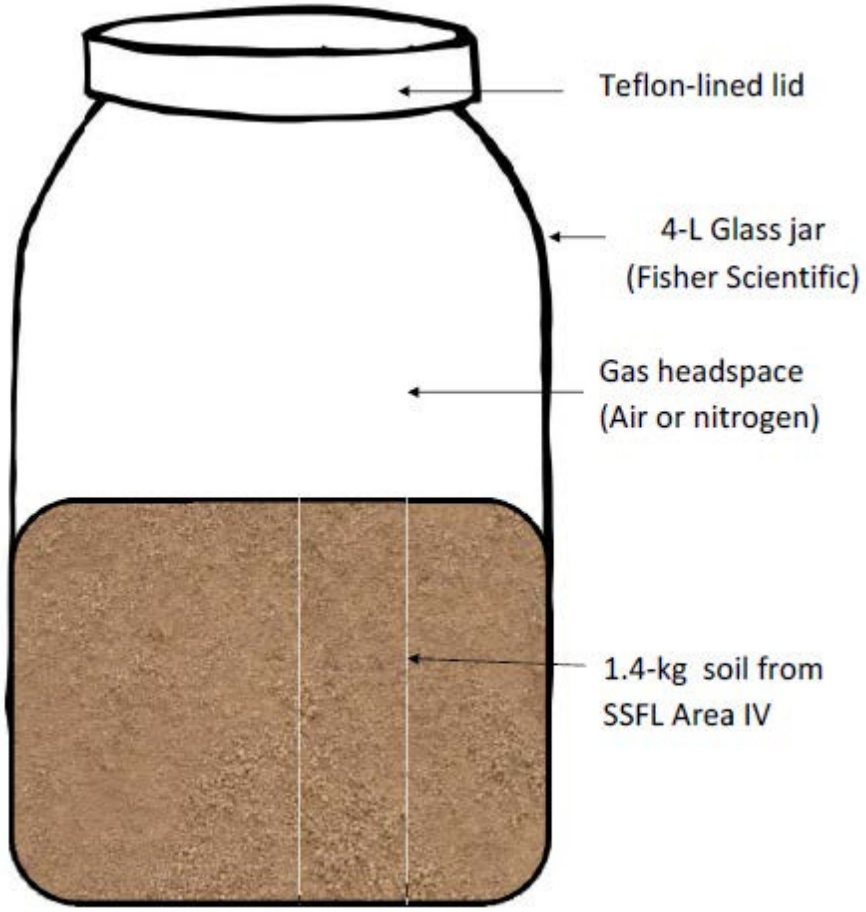

Figure 1: Glass jars for laboratory microcosms (not to scale)

5.2 Experimental Design and Microcosm Types

This section provides an overview of the ten (if anaerobic soils are found to be present at Area IV; nine if anaerobic soils are not sound) types of microcosms for the bioremediation soil treatability study. Five replicates of each microcosm type will be prepared, for a potential total of fifty microcosms. The microcosm experimental design and operation is summarized in Table 2.

There will be five unamended microcosm types for the bioremediation study, if anaerobic soils are found to be present at Area IV. There will be four unamended microcosm types for the study, if anaerobic soils are not found at Area IV. The different unamended microcosm types for the study will include:

- Unamended soil from sample location 5C_DG-516
- Unamended soil from sample location 5C_DG-755
- Unamended soil from sample location PUBS1044
- Unamended soil from the anaerobic sample location (conditional - if anaerobic soils are found to be present at Area IV)
- Unamended sterilized control using soil from sample location 5C_DG-516

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There will be five amended microcosm types for the study. Amendments will be added to the microcosm soils only at the beginning of the study. The five types of amended microcosms will all use soil from sample location 5C_DG-516. The different types of amendments used in these microcosm types include:

- Biosurfactant Amendment: de-oiled soya lecithin granules will be added to the soils at 1.5% weight/weight
- Nutrient Amendment: Miracle-Gro® with a Nitrogen-Phosphorus-Potassium ratio of 24-8-16 will be added to the soils at 5.1 mg nitrogen/kg soil. This amendment ratio may be adjusted once COI concentrations in the soil samples are determined by the contract laboratory
- Rice Hull Amendment: rice hulls will be added to the soils at 10% weight/weight
- Bioaugmentation with *P. chrysosporium*: rice hulls augmented with *P. chrysosporium* and malt extract will be added to the soils at 10% weight/weight. *P. chrysosporium* is one of the few microorganisms that shows promise to degrade all COIs
- Combined Amendments: nutrients, biosurfactant, and rice hulls augmented with *P. chrysosporium* and malt extract will be added to the soils at the ratios discussed above

Unamended soils from Sample Location 5C_DG-516

Five unamended aerobic microcosms will be used to help assess baseline aerobic COI degradation rates (from natural attenuation processes) for Area IV. The five microcosms will not be sterilized, will not be bioaugmented, and will not have nutrients, biosurfactants, or rice hulls added. These five unamended microcosms will have soil from sample location 5C_DG-516. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

Unamended soils from Sample Location 5C_DG-755

Five unamended aerobic microcosms will be used to help assess baseline aerobic COI degradation rates (from natural attenuation processes) for Area IV. The five microcosms will not be sterilized, will not be bioaugmented, and will not have nutrients, biosurfactants, or rice hulls added. These five unamended microcosms will have soil from sample location 5C_DG-755. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

Unamended soils from Sample Location PUBS1044

Five unamended aerobic microcosms will be used to help assess baseline aerobic COI degradation rates (from natural attenuation processes) for Area IV. The five microcosms will not be sterilized, will not be bioaugmented, and will not have nutrients, biosurfactants, or rice hulls added. These five unamended microcosms will have soil from sample location PUBS1044. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

Unamended soils from Anaerobic Sample Location (conditional)

Five unamended anaerobic microcosms will be used to help assess a baseline anaerobic COI degradation rate (from natural attenuation processes) for Area IV, if anaerobic soils are found to be present at Area IV. The five microcosms will not be sterilized, will not be bioaugmented, and will not have nutrients, biosurfactants, or rice hulls added. The five microcosms will have soil from the anaerobic sampling location. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

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Unamended sterilized control using soil from Sample Location 5C_DG-516

Five sterilized microcosms will be used to determine a COI degradation rate for unamended soils in the absence of bacteria and fungi, or other biodegradation activity. These microcosms will test for potential abiotic COI losses during incubation of the microcosms. The soils for these microcosms will be sterilized by a licensed contract laboratory using a Cobalt-60 source for gamma irradiation. These five microcosms will contain soil from sample location 5C_DG-516. The five microcosms will not be bioaugmented, and will not have nutrients, biosurfactants, or rice hulls added. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

Biosurfactant Amendment using soil from Sample Location 5C_DG-516

Five aerobic microcosms will be used to determine if the addition of a biosurfactant to Area IV soils can increase biodegradation rates of the soil COIs. The five microcosms will not be sterilized, will not be bioaugmented, and will not have nutrients or rice hulls added. De-oiled soya lecithin granules will be added to the microcosm soils at 1.5% weight/weight. These five microcosms will have soil from sample location 5C_DG-516. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

Nutrient Amendment using soil from Sample Location 5C_DG-516

Five aerobic microcosms will be used to determine if the addition of nutrients to Area IV soils can increase biodegradation rates of the soil COIs. The five microcosms will not be sterilized, will not be bioaugmented, and will not have biosurfactants or rice hulls added. Miracle-Gro All-Purpose Plant Food will be added to the microcosm soils at the equivalent of 5.1 mg nitrogen per kilogram of soil. The five microcosms will have soil from sample location 5C_DG-516. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

Rice Hull Amendment using soil from Sample Location 5C_DG-516

Five aerobic microcosms will be used to determine if the addition of rice hulls to Area IV soils can increase biodegradation rates of the soil COIs. Rice hulls may aid in biodegradation of the COIs through increased soil aeration and/or serve as a supplemental carbon source for native bacteria and/or fungi. The five microcosms will not be sterilized, will not be bioaugmented, and will not have biosurfactants or nutrients added. Rice hulls will be added to these microcosm soils at a ratio of 10% weight/weight. The five microcosms will have soil from sample location 5C_DG-516. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

Bioaugmentation with P. chrysosporium using soil from Sample Location 5C_DG-516

Five aerobic microcosms will be used to determine if bioaugmentation can increase biodegradation rates and/or facilitate end-product degradation mechanisms of the Area IV soil COIs. The five microcosms will not be sterilized, and will not have biosurfactants or nutrients added. Freeze-dried *P. chrysosporium* will be inoculated on rice hulls with malt extract and added to the bioaugmentation microcosms. The total mass of rice hulls added will be the same as that added to the rice-hull only microcosms (10% weight/weight). The five microcosms will have soil from sample location 5C_DG-516. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

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Combined Amendments using soil from Sample Location 5C_DG-516

Five aerobic microcosms will be used to determine if a combination of the above amendments can increase biodegradation rates and/or facilitate end-product degradation mechanisms of the Area IV soil COIs. The five microcosms will not be sterilized. The microcosms will be augmented with all of the aforementioned amendments (1.5% weight/weight soya lecithin, Miracle-Gro, and a 10% weight/weight rice hull mixture containing 50% weight/weight P. chyrsosporium-augmented hulls). The five microcosms will have soil from sample location 5C_DG-516. The microcosms will be incubated at site soil temperature for 9 months and soil samples will be collected from the microcosms for COI analyses after 0, 4, and 9 months of operation.

Table 1. Required sample mass and target sample volumes for analyses

Analyte	Subcontract Laboratory Required Soil Mass[a] (gram)	Subcontract Laboratory Target Soil Volume (ounce)	Subcontract Laboratory Required Liquid Volume (milliliter)
PCB	30	8[b]	1000
Dioxins[b]	10	4	1000
PAH	30	8[b]	1000
TPH	15	8[b]	1000
Percent Moisture	10	8[b]	Not Applicable
Nitrogen	75	8[b]	250
Organic Carbon	50	8[b]	500
Total	**220**	12[b]	**4750**

a: These masses are based on estimated soil moisture of 12% weight/weight.
b: A single 8-ounce sample jar will be collected for PCBs, PAHs, TPH, and moisture analyses by EMAX laboratory. A single 4-ounce sample jar will be collected for dioxin, nitrogen, and organic carbon analyses by Lancaster laboratory.

Table 2. Microcosm experimental design and operation

Amendment	Sterilized?	Soil Sample Location	Sample Intervals
No amendment	Sterilized	5C_DG-516	0, 4, and 9-months
No amendment	Unsterilized	5C_DG-516	0, 4, and 9-months
No amendment	Unsterilized	5C_DG-755	0, 4, and 9-months
No amendment	Unsterilized	PUBS1044	0, 4, and 9-months
No amendment	Unsterilized	Anaerobic sample location (conditional)	0, 4, and 9-months
Nutrient (Miracle-Gro)	Unsterilized	5C_DG-516	0, 4, and 9-months
Rice hulls	Unsterilized	5C_DG-516	0, 4, and 9-months
Rice hulls, nutrient, malt extract, and *P. chrysosporium* fungi	Unsterilized	5C_DG-516	0, 4, and 9-months
Biosurfactant (soya lecithin)	Unsterilized	5C_DG-516	0, 4, and 9-months
Biosurfactant, rice hulls, nutrient, malt extract, and *P. chrysosporium fungi*	Unsterilized	5C_DG-516	0, 4, and 9-months

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5.3 Moisture Content Measurement and Adjustment

Use ASTM Method D 2216-10 to determine soil moisture content prior to microcosm set-up. Soil moisture will be adjusted using deionized water to obtain the desired moisture content of 15% weight/weight. 15% moisture content was found to be the optimal moisture percentage in previous bioremediation studies (e.g., Rastegarzadeh, Nelson, and Ririe, 2006). Historic soil moisture measurements made for Area IV soils indicate that soil moisture is less than 15%. For the microcosms receiving nutrient amendment, the nutrient amendment (Miracle-Gro) will be dissolved in the deionized water before adding it to the microcosms.

After the soil moisture content is adjusted, the microcosms will be sealed air-tight to avoid potential change in moisture content during incubation. Moisture content will not be readjusted during the sampling events.

Moisture content will be adjusted in a fully functional fume hood (for applicable aerobic soils) or a laboratory glovebox with a nitrogen purge (for anaerobic soils) according to the following steps:

1. Put on PPE.
2. Calculate soil moisture content using ASTM Method D2216-10.
3. Calculate amount of moisture needing to be added or subtracted in order to reach a soil moisture content of 15% weight/weight.
4. Adjust soil moisture content to 15% weight/weight. If the soil moisture content is above 15%, the soil will be allowed to air dry in the jar with the lid removed in a fume hood or nitrogen-purged glovebox until a moisture content of 15% is reached. Steps 5 and 6 of this procedure will then be followed. If the moisture content is below 15%, Steps 3 through 6 will be followed.
5. Measure out required volume of deionized water into an acid-washed graduated cylinder to adjust the soil moisture content.
6. Unscrew microcosm lid. Quickly and carefully pour the measured deionized water from the graduated cylinder into the opened microcosm.
7. Mix the microcosm soil using a double acid washed stainless steel spatula for two minutes or until added deionized water is evenly incorporated (if applicable).
8. Re-seal the microcosm lid tightly.

5.4 Microcosm Preparation

Unamended Aerobic Microcosm Preparation

1. Double acid wash the 4-liter glass jars using 10% trace-metal grade nitric acid. Rinse with deionized water and allow jars to air-dry.
2. Use a #4 sieve (4.750 mm opening) to remove any debris or large rocks from the soil sample.
3. Weigh out 1.4 kg dry weight of soil and place the soil into the acid washed and air-dried jar for each microcosm.
4. Adjust soil moisture content if needed as described above.
5. Mix the microcosm soil using a double acid washed stainless steel spatula for two minutes or until added deionized water is evenly incorporated (if applicable).
6. Seal microcosm with Teflon-lined lid.

Sterilized Microcosm Preparation

1. Double acid wash the 4-liter glass jars using 10% trace-metal grade nitric acid. Rinse with deionized water and allow the glass jars to air-dry.
2. Use a #4 sieve (4.750 mm opening) to remove any debris or large rocks from the soil sample.
3. Sterilize the soil using gamma irradiation with Cobalt-60. This irradiation will occur at an appropriately licensed contract facility. Approximately 8 kg total dry weight of soil will be sterilized for the five sterilized aerobic microcosms.

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4. Weigh out 1.4 kg dry weight sterilized soil and place the soil into the acid washed and air-dried jar for each microcosm. Sterilized microcosms will not have their soil moisture content adjusted to avoid introducing bacteria and fungi, or other microbial species to the sterilized soils.
5. Seal microcosm with Teflon-lined lid.

Miracle-Gro Microcosm Preparation:

1. Double acid wash the 4-liter glass jars using 10% trace-metal grade nitric acid. Rinse with deionized water and allow the glass jars to air-dry.
2. Use a #4 sieve (4.750 mm opening) to remove any debris or large rocks from the soil sample.
3. Weigh out 1.4 kg dry weight of soil and place the soil into the acid washed and air-dried jar for each microcosm.
4. Weigh out required mass of solid-phase Miracle-Gro to satisfy concentration-specific nutrient requirements. The required mass of Miracle-Gro will be determined by the Cal Poly Bioremediation Team pending the analytical chemistry analyses of the bulk homogenized soils.
5. Prepare a solution of the volume of water required to obtain 15% soil moisture content with the required mass of solid-phase Miracle-Gro. Prepare this solution in a double acid washed glass beaker. Mix solution on a magnetic stir plate using a double acid washed magnetic stir bar for five minutes.
6. Mix the solution with the microcosm soil using a double acid washed stainless steel spatula for two minutes or until evenly incorporated.
7. Seal microcosm with Teflon-lined lid.

Soya Lecithin Microcosm Preparation:

1. Double acid wash the 4-liter glass jars using 10% trace-metal grade nitric acid. Rinse with deionized water and allow the glass jars to air-dry.
2. Use a #4 sieve (4.750 mm opening) to remove any debris or large rocks from the soil sample.
3. Weigh out 1.4 kg dry weight of soil and place the soil into the acid washed and air-dried jar for each microcosm.
4. Weigh out 21 grams of soya lecithin per microcosm
5. Prepare a solution of the volume of water required to obtain 15% soil moisture content with the required mass of soya lecithin. Prepare this solution in a double acid washed glass beaker. Mix solution on a magnetic stir plate using a double acid washed magnetic stir bar for five minutes.
6. Mix the solution with the microcosm soil using a double acid washed stainless steel spatula for two minutes or until evenly incorporated.
7. Seal microcosm with Teflon-lined lid.

Rice Hull Microcosm Preparation:

1. Double acid wash the 4-liter glass jars using 10% trace-metal grade nitric acid. Rinse with deionized water and allow the glass jars to air-dry.
2. Autoclave 700 g of rice hulls at 121°C for one hour and air dry them.
3. Use a #4 sieve (4.750 mm opening) to remove any debris or large rocks from the soil sample.
4. Weigh out 1.4 kg dry weight of soil and place the soil into the acid washed and air-dried jar for each microcosm.
5. Weigh out 140 g of autoclaved rice hulls and then place in each microcosm.
6. Adjust soil moisture content if needed as described above.
7. Mix the rice hulls and deionized water with the microcosm soil using a double acid washed stainless steel spatula for two minutes or until evenly incorporated.
8. Seal microcosm with Teflon-lined lid.

Inoculated Rice Hull Microcosm Preparation

1. Double acid wash the 4-liter glass jars using 10% trace-metal grade nitric acid. Rinse with deionized water and allow the glass jars to air-dry.
2. Use a #4 sieve (4.750 mm opening) to remove any debris or large rocks from the soil sample.

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3. Weigh out 1.4 kg dry weight soil and place the soil into the acid washed and air-dried jar for each microcosm.
4. Autoclave 700 g of rice hulls for 1 hour at 121°C.
5. Adjust moisture content of the rice hulls to 60% using deionized water and 3 g/L malt extract.
6. Add *P. chrysosporium* slant agar pieces to moistened rice hulls.
7. Vigorously mix by shaking the rice hull and slant agar piece mixture in an autoclaved, sealed container. Incubate at 39°C for one week.
8. Weigh out 140 g dry weight of inoculated rice hulls and add to microcosm using a using a double acid washed stainless steel spatula.
9. Adjust soil moisture content to obtain 15% soil moisture. Mix with spatula for two minutes or until evenly incorporated.
10. Seal microcosm with Teflon-lined lid.

Combination Treatment Microcosm Preparation

1. Double acid wash the 4-liter glass jars using 10% trace-metal grade nitric acid. Rinse with deionized water and allow the glass jars to air-dry.
2. Use a #4 sieve (4.750 mm opening) to remove any debris or large rocks from the soil sample.
3. Weigh out 1.4 kg dry weight soil and place the soil into the acid washed and air-dried jar for each microcosm.
4. Weigh out required mass of Miracle-Gro to satisfy concentration-specific nutrient requirements. Prepare a stock solution including Miracle-Gro, soya lecithin, and 3 g/L malt extract with the volume of water required to obtain 15% moisture content in soils.
5. Mix solution on a magnetic stir plate for five minutes.
6. Add one-fifth of solution into each microcosm.
7. Add 140 g of inoculated rice hulls into each microcosm.
8. Mix soil, inoculated rice hulls, and the prepared solution with a double acid washed stainless steel spatula for two minutes or until evenly incorporated.
9. Seal microcosm with Teflon-lined lid.

Anaerobic Microcosm Preparation (if anaerobic soils are present at Area IV)

1. Double acid wash the 4-liter glass jars using 10% trace-metal grade nitric acid. Rinse with deionized water and allow the glass jars to air-dry.
2. Transfer soils, balance, stainless steel spatula, weigh boats, double acid washed 4-liter glass jars, #4 sieve (4.750 mm opening) to glove box.
3. Purge glove box with nitrogen.
4. Use the #4 sieve to remove any debris or large rocks from the soil sample.
5. Weigh out 1.4 kg dry weight soil and place into the acid washed and air-dried jar for each microcosm.
6. Adjust soil moisture content if needed as described above.
7. Mix the microcosm soil using a double acid washed stainless steel spatula for two minutes or until added deionized water is evenly incorporated (if applicable).
8. Seal microcosm with Teflon-lined lid.

5.6 Microcosm Sampling

Soil will be sampled after they are placed in the microcosms and mixed with amendments, and after approximately 4 and 9 months of microcosm operation using an uncontaminated ½-inch stainless steel decontaminated push tube. The push tube will be decontaminated per SSFL SOP ST PHY 7, *Laboratory Sampling Equipment Decontamination*. The actual sampling time will be based on the Cal Poly Bioremediation Team's professional judgment. Samples will be shipped to a contract laboratory under SSFL SOP 11, *Packaging and Shipping Environmental Samples*. A target soil volume of 4-ounces collectively for dioxin, organic carbon, and nitrogen analyses and 8-ounces collectively for PCBs, PAHs, TPH, and moisture analyses will be collected. Soil samples will be sent to two contract laboratories. Lancaster laboratory will be performing dioxin, organic carbon, and nitrogen analyses and the EMAX laboratory will be performing PCB, PAH, TPH, and moisture analyses.

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The required sample masses are presented in Table 1. The analytical methods are presented in Table 3.

Table 3: Method number/title for contract laboratory chemical analysis of soils

Analyte	Analytical Method for Soil	Analytical Method for Liquid
PCBs	EPA Method 8082A Gas Chromatograph/Electron Capture Detector	EPA Method 8082A Gas Chromatograph/Electron Capture Detector
Dioxins	EPA Method 1613B Gas Chromatograph/ High Resolution Mass Spectroscopy	EPA Method 1613B Gas Chromatograph/ High Resolution Mass Spectroscopy
PAHs	EPA Method 8270C/D SIM Gas Chromatograph/ High Resolution Mass Spectroscopy	EPA Method 8270C/D SIM Gas Chromatograph/ High Resolution Mass Spectroscopy
TPH	EPA Method 8015B/C/D Gas Chromatograph/Flame Ionization Detector	EPA Method 8015B/C/D Gas Chromatograph/Flame Ionization Detector
Percent Moisture	ASTM D2216	Not applicable
Nitrogen	ASTM D5373	ASTM D5373
Organic Carbon	SM 5310B	SM 5310B

6.0 Documentation

Document all activities, SSFL SOP ST PHY 10, *Cal Poly Laboratory Data Collection, Documents, Content, and Control*. Document deviations from this SOP and justifications for those deviations, if any.

7.0 References

Rastegarzadeh, L., Y. Nelson, and G.T. Ririe 2006. "Biotreatment of Synthetic Drill-Cutting Waste in Soil. *Proceedings of the 5th International Conference on Remediation of Chlorinated and Recalcitrant Compounds,* Monterey, CA May.

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Terminal Restriction Fragment Length Polymorphism (TRFLP) Analysis of In-situ Microbial Community Structure

SSFL SOP ST BIO 2
Revision: 0
Date: December 2013

Prepared: Y. Nelson (California Polytechnic State University) / K. Roberts (CDM Smith)

Technical Review: P. Sharma

QA Review: J. Oxford

Approved and Issued: December 13, 2013

1.0 Objective

The objective of this technical standard operating procedure (SOP) is to define the techniques and requirements for conducting Terminal Restriction Fragment Length Polymorphism (TRFLP) analyses for Phase 1 of the bioremediation soil treatability study.

2.0 Background

The bioremediation soil treatability study is one of five soil treatability studies commissioned by the US Department of Energy (DOE) as part of the process to identify a remediation technology for Area IV of the Santa Susana Field Laboratory (SSFL). The bioremediation study will be conducted in two phases. Phase 1 will involve collecting samples from Area IV soils to identify contaminant degrading bacteria and fungi currently present in Area IV soils. Phase 2 will use laboratory soil microcosms to determine the likely extents and rates of biodegradation occurring in Area IV and investigate the potential of biostimulation (addition of nutrients, surfactants, etc.) and/or bioaugmentation (addition of additional microorganisms) to increase contaminant biodegradation rates and/or facilitate end-product degradation mechanisms. This SOP addresses the TRFLP analyses to determine the microbial community structure in Area IV soils during Phase 1 of the treatability study.

2.1 Definitions

Cal Poly Bioremediation Team is composed of members of California Polytechnic State University (Cal Poly) who will be participating in the bioremediation soil treatability study for Area IV of SSFL. The Cal Poly Bioremediation Team includes faculty, research associates, graduate students, and undergraduate students.

CDM Smith Team is composed of employees of CDM Smith and its subcontractors, excluding Cal Poly.

TRFLP is a genetic analysis method that provides a profile of microbial communities present in environmental samples by analyzing amplified DNA fragments. TRFLP analysis of in-situ microbial community structure is discussed in detail in Kitts, 2001. Dr. Kitts, the author of the referenced paper, is one of the researchers on the bioremediation treatability study.

2.2 Associated Procedures

- SSFL SOP ST PHY 10, *Cal Poly Laboratory Data Collection, Documents, Content, and Control*
- SSFL SOP ST BIO 3, *Guide to Handling Bioremediation Treatability Experiment-Derived Waste*

3.0 General Responsibilities

Cal Poly Bioremediation Team will be responsible for conducting the TRFLP procedures and analyzing the results.

CDM Smith Team will provide experiment oversight and soil sample collection in the field.

4.0 Required Equipment

TRFLP analyses require the following materials:

- MoBio Power Soil DNA Extraction kit
- Personal protective equipment (PPE), including nitrile gloves, eye protection, and laboratory coat
- Lab-bench vortex
- Centrifuge
- Centrifuge spin filters

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- BR DNA Pico Green stain
- Life Sciences Qubit fluorometer
- 1.5% electrophoresis gel
- MoBio PCR Ultra-Clean kit
- Area IV soil samples
- Laboratory logbook and bench sheet forms
- Indelible black or blue ink pens and markers
- PCR machine
- Freezer capable of -20°C temperatures
- Balance, with a sensitivity of at least 0.1 gram (g)
- Micropipetters and tips
- Plastic microcentrifuge tubes and plates
- Beckman CEQ 8000 DNA Sequencer System
- Formamide and 600 base-pair standard (Beckman Coulter)
- PCR reagents (Promega)
- Restriction enzymes (New England Biolabs)
- PCR primers (Fisher and Sigma Aldrich)
- 95% ethanol
- 70% ethanol
- 3Molar (M) Sodium acetate
- Glycogen
- Paper towels
- Mineral oil
- Bio-Tek Fluorometer

5.0 Procedures

To perform a TRFLP analysis, deoxyribonucleic acid (DNA) is extracted from a soil sample and then amplified using polymerase chain reaction (PCR). The PCR uses specific primers for specific types of microorganisms. The amplified DNA is then cut with restriction enzymes, resulting in fragments of DNA with varying sizes. These fragments are labeled with a fluorescent tag that is read by a capillary sequencer. The lengths of the fragments are determined and the pattern of resulting fragment lengths can be used to characterize the microbial diversity of the soil sample. Comparison of observed TRFLP patterns to libraries of TRFLP patterns for known microorganisms can be used to infer the presence of certain types of microorganisms. Step-by-step details of these laboratory procedures are provided below.

5.1 DNA Extraction from Soil Sample

1. Don appropriate PPE
2. Using the MoBio Power Soil DNA Extraction Kit, add 1 g of soil sample to the provided 2-milliliter (ml) PowerBead Tubes.
   The PowerBead Tube contains a buffer that will help disperse the soil particles, begin to dissolve humic acids, and protect nucleic acids from degradation.
3. Gently vortex the PowerBead Tubes. A standard lab-bench vortex will be used and the rate of vortexing will be a rate that produces a vortex in the tube.
4. Check Solution C1 from the MoBio Power Soil DNA Extraction Kit. If Solution C1 is precipitated, heat solution to 60°C until dissolved before use.
5. Add 60 microliters (μL) of Solution C1 into the PowerBead Tube and vortex this solution as follows:
   -Soil: 5.0 meters/second (m/s) for 45 seconds.
   -Pure culture: 4.5 m/s for 30 seconds
6. Centrifuge the PowerBead Tube at 10 x kg for 30 seconds.
7. Transfer the supernatant from the PowerBead Tube to a new microcentrifuge tube (provided in MoBio Power Soil DNA Extraction Kit).

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8. Add 250 μL of Solution C2 from the MoBio Power Soil DNA Extraction Kit and vortex for 5 seconds.
9. Place the microcentrifuge tube in a freezer for 10 to 15 minutes, until the samples reach approximately 4°C.
10. Centrifuge the chilled microcentrifuge tube for 1 minute at 10 x kg.
11. Avoiding the pellet mass in the bottom of the tube, pipet up to 600 μL of supernatant from the microcentrifuge tube to a new microcentrifuge tube.
12. Add 200 μL of Solution C3 from the MoBio Power Soil DNA Extraction Kit to the microcentrifuge tube and vortex for 30 seconds.
13. Place the microcentrifuge tube in a freezer for 10 to 15 minutes, until the samples reach approximately 4°C.
14. Centrifuge the microcentrifuge tube for 1 minute at 10 x kg.
15. Transfer up to 750 μL of the supernatant to a clean microcentrifuge tube (provided in MoBio Power Soil DNA Extraction Kit).
16. Add 1.2 ml of Solution C4 from the MoBio Power Soil DNA Extraction Kit to the supernatant in the microcentrifuge tube and vortex for 5 seconds.
17. Load approximately 675 μL of the vortexed solution onto a spin filter and centrifuge at 10 x kg for 1 minute.
18. Discard the flow through and add an additional 675μL of supernatant to the spin filter and centrifuge at 10 x kg for 1 minute.
19. Load the remaining supernatant onto the spin filter and centrifuge at 10 x kg for 1 minute.
    Note: A total of three loads for each sample processed are required.
20. Add 500 μL of Solution C5 from the MoBio Power Soil DNA Extraction Kit to the spin filter and centrifuge for 30 seconds at 10 x kg.
21. Discard the flow through from the collection tube. This flow through fraction is non-DNA organic and inorganic waste removed from the silica spin filter membrane by the ethanol wash solution and can be disposed of in a normal laboratory drain.
22. Centrifuge the spin filter for 1 minute.
23. Carefully place spin filter in a new clean tube (provided in MoBio Power Soil DNA Extraction Kit).
24. Add 100 μL of Solution C6 from the MoBio Power Soil DNA Extraction Kit to the center of the white filter membrane and let sit for 15 minutes.
25. Centrifuge for the white filter membrane 30 seconds.
26. Discard the spin filter.
27. Store DNA frozen at -20° to -80°C. DNA can remain in this state indefinitely.

5.2 Quantify DNA

1. Stain DNA with BR DNA Pico Green stain.
2. Quantify DNA by measuring fluorescence with a Life Sciences Qubit fluorometer.
3. Use 10 nanogram (ng) of DNA for each PCR reaction.

5.3 Amplify DNA using PCR

1. The forward primer is labeled with a Cy5 fluorescent tag.
   Note: Two control reactions are needed to determine if the Cy5 tag is working: closed negative (free of external DNA) and positive (DNA known to amplify with PCR conditions).Regarding the positive control reactions, use:
   - *E. coli* for general 16S eukaryotes
   - *Pichia farinose* for fungi
   - *H. volcanii* for archea bacteria

2. Run three reactions for each sample. The three reactions will be combined in a later step.

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3. Use the following cycling parameters:
   - 94°C for 10 minutes
   - 30 cycles of (94°C for 1 minute, 46.5°C for 1 minute, 72°C for 2 minutes)
   - 72°C for 10 minutes
   - Hold at 4°C

5.4 Electrophoresis

Run 3 to 5 μL of PCR product on a 1.5% gel for 20 to 25 minutes at 80 to 100V.

5.5 Combine the PCR replicates and remove leftover salts, dNTPs, and primer

1. Using the MoBio PCR Ultra-Clean kit, add 5 volumes (250 μL) of SpinBind solution to each replicate sample.
   Note: Move the pipet up and down to mix the solution in the well.
2. Transfer 160 μl from each replicate to the spin filter unit.
   Centrifuge the spin filter unit with the replicates for 30 seconds at 10 x kg.
3. Discard the liquid that elutes through the filter (eluate).
4. Repeat step 3 until all PCR SpinBind mixture is filtered.
5. Add 300 μl of SpinClean buffer to spin filter.
6. Centrifuge spin filter for 30 seconds at 10 x kg.
7. Discard eluate.
8. Centrifuge spin filter for 120 seconds at 10 x kg to remove any remaining fluid.
9. Transfer spin filter to clean 2.0 ml collection tube.
10. Add 60 μl of PCR water to spin filter.
11. Incubate spin filter for 10 minutes.
12. Centrifuge spin filter for 60 seconds at 10 x kg.
13. Discard spin filter and store the PCR product that is in the tube at –20°C.

5.5 PCR Product Concentration

Using the Bio-Tek Fluorometer determine the PCR product concentration by measuring the Cy5 incorporated fluorescent label from the forward primer.

5.6 Produce the Labeled Fragments from Enzyme Digests

1. Set up digests in the Beckman CEQ 8000 DNA Sequencer System (CEQ) 96 well plate. The ethanol precipitation will also be performed in this plate. Once the ethanol precipitation is complete, the formamide and 600 base pair standard will be added to the plate and the plate put in the CEQ for fragment analysis.

   - For the Area IV samples, use 30 ng of DNA.
   - For the E. coli standard, use 5 to 10 ng of a E. coli digest standard.
   - For DpnII (10,000 enzyme activity unit/mL) use 1.0 μL enzyme and 4 μL buffer (comes with the enzyme) per tube. Add DNA and water to bring the volume 40 μL.
   - For HaeIII (10,000 enzyme activity unit /mL) use 1.0 μL enzyme and 4 μL buffer (comes with the enzyme) per tube. Add DNA and water to bring the volume to 40 μL.
2. Cycle the tubes in PCR machine for 4 hours at 37°C.
3. Cycle to either 65°C for DpnII or 80°C for HaeIII for 20 minutes to deactivate the enzyme.
4. Hold at 4°C.
5. Store the digests at -20°C until ready for ethanol precipitation (Section 5.7).

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5.7 Ethanol Precipitation

1. To the digest in the microcentrifuge tubes (from Section 5.6), add 100 μL of 4°C 95% ethanol and 2 μl 3M Sodium Acetate pH 4.6 (5% digest volume) and 1 μL glycogen (20 mg/mL).
2. Make sure lids are on and invert plate five times to mix.
3. Place the tubes in the -20°C freezer for 30 minutes.
4. Centrifuge the tubes for 15 minutes at 5,300 revolutions per minute (RPM).
5. Remove ethanol by inverting the PCR tray on a paper towel.
6. Add 100 μL of cold 70% ethanol.
7. Centrifuge the tubes for 5 minutes at 5,300 RPM.
8. Remove ethanol by inverting the PCR tray on a paper towel.
9. Centrifuge rack in inverted position on top of a paper towel for 1 minute at 700 RPM.
10. Store the DNA in the -20°C freezer until ready to proceed to CEQ preparation (Section 5.8).

5.8 CEQ Sample Preparation and Analysis

1. Prepare master mix in microcentrifuge tubes of 20 μL formamide and 0.25 μL 600 base pair standard per reaction.
2. Add 20 μL of the master mix to each tube from Section 5.7.
3. Add enough mineral oil to the top of each well to cover the mix and prevent sample evaporation.
4. Place the well in the CEQ.
5. Run the Beckman CEQ using the system method “TRF” with a capillary temperature of 60°C, denature temperature of 90°C, and duration of 180 seconds, inject voltage 5.0 kilovolts (kV), duration 5 seconds, separate voltage 5.0 kV duration 65 minutes.
6. Examine resulting TRFLP patterns.

6.0 Documentation

Document all activities, per SSFL SOP ST PHY 10, *Cal Poly Laboratory Data Collection, Documents, Content, and Control*. Document deviations from this SOP and justifications for those deviations, if any.

7.0 References

Kitts, C.L. 2001. Terminal Restriction Fragment patterns: A Toll for Comparing Microbial Communities and Assessing Community Dynamics. Curr. Issues Intest. Microbiol. 2(1):17-25

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Guide to Handling Bioremediation Treatability Experiment-Derived Waste

SSFL SOP ST BIO 3
Revision: 1
Date: February 2014

Prepared:	California Polytechnic State University & K. Roberts (CDM)	**Technical Review:**	C. Werden
QA Review:	J. Oxford	**Approved and Issued:**	February 12, 2014

1.0 Objective

This technical standard operating procedure (SOP) presents criteria for the management of experiment-derived waste (EDW) generated at California Polytechnic State University (Cal Poly) facilities during bioremediation soil treatability experiments. The primary objectives for managing EDW are minimizing the quantity of EDW and complying with applicable regulations for waste disposal.

2.0 Background

The bioremediation soil treatability study is one of five soil treatability studies commissioned by the US Department of Energy (DOE) as part of the process to identify a remediation technology for Area IV of the Santa Susana Field Laboratory (SSFL). The bioremediation study will be conducted in two phases. Phase 1 will involve collecting samples from Area IV soils to identify contaminant-degrading bacteria and fungi currently present in the soils. Phase 2 will use laboratory soil microcosms to determine the likely extents and rates of biodegradation occurring in Area IV. Phase 2 will also investigate the potential of biostimulation (addition of nutrients, surfactants, bulking agents, etc.) and/or bioaugmentation (addition of microorganisms) to increase contaminant of interest (COI) biodegradation rates and/or facilitate end-product degradation mechanisms. This SOP addresses the handling of EDW generated by the Cal Poly laboratory experiment portions of Phases 1 and 2.

Soils used in laboratory experiments will be containerized and stored in a secure location at Cal Poly after bioremediation treatability experiments are complete. Only Cal Poly researchers and graduate students will have access to this location. CDM Smith will arrange to have these containerized soils returned to Area IV of SSFL. The soils will remain in their containers at Area IV until full scale site remediation begins at Area IV. At that time, these soils and tissues will be treated with other contaminated Area IV soils. These soils that are returned to Area IV from Cal Poly are not considered EDW.

2.1 Definitions

Cal Poly Bioremediation Team is composed of members of Cal Poly who will be participating in the bioremediation treatability study for Area IV of SSFL. The Cal Poly Bioremediation Team includes faculty, research associates, graduate students, and undergraduate students.

CDM Smith Team is composed of employees of CDM Smith and its subcontractors, excluding Cal Poly.

Experiment-Derived Wastes are discarded materials resulting from laboratory activities such as experiment operation, sampling, culturing, testing, and decontamination processes that, in present form, possess no inherent value or additional usefulness without treatment. Wastes will be personal protective equipment, (e.g., nitrile gloves, paper towels, polyethylene sheeting), decontamination fluids, wastes produced from Terminal Restriction Fragment Length Polymorphism (TRFLP) analysis, and wastes produced from culturing COI-degrading microorganisms.

California Environmental Protection Agency Department of Toxic Substances Control (DTSC) is the regulating agency that will review and approve disposal plans.

2.2 Associated Procedures

- SSFL SOP ST PHY 10, *Cal Poly Laboratory Data Collection, Documents, Content, and Control*
- SSFL SOP ST BIO 1, *Bioremediation Microcosm Preparation and Operation*
- SSFL SOP ST BIO 2, *TRFLP Analysis*

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3.0 General Responsibilities

Cal Poly Bioremediation Team will perform all bioremediation laboratory experiments except for chemical analyses of soils. The Cal Poly Bioremediation Team will be responsible for implementing this SOP during bioremediation soil treatability laboratory experiments and properly containerizing and disposing of TRFLP and culturing wastes, disposing of solid EDW, and containerizing and staging liquid EDW during the tests. The Cal Poly Bioremediation Team will also be responsible for the proper disposal of the wastes produced from TRFLP analyses and from culturing COI-degrading microorganisms.

CDM Smith Team will collect all soils used in bioremediation laboratory experiments and arrange for sampling, proper transport and disposal of liquid EDW from Cal Poly. The CDM Smith Team will supply the EDW containment device to Cal Poly. The CDM Smith Team will also supply containment devices for the collection of SSFL soils used in the bioremediation treatability experiments at Cal Poly. The CDM Smith Team will arrange for these soils to be returned to SSFL.

4.0 Composition and Disposal of TRFLP Analysis Wastes

Approximately 20 microliters (µL) of formamide and 2 milliliters (mL) of a waste mixture will be produced from each TRFLP analysis performed by Cal Poly. The waste mixture will include:

- guanidine thiocyanate (approximately 17% of total volume)
- sodium dodocyl sulfate (approximately 1% of total volume)
- acetate (approximately 9% of total volume)
- guanidine hydrochloride (approximately 55% of total volume), and
- ethanol (approximately 18% of total volume).

Waste storage and disposal will be as follows:

1. The co-mingled formamide and waste mixture will be stored in dated 500 mL plastic bottles with screw-top lids.
2. The waste bottle will be stored in the Cal Poly TRFLP laboratory until the bottle is either full or one year has elapsed since the first contents were put in the bottle, whichever occurs first.
3. The Cal Poly laboratory manager will contact Cal Poly Facilities Services-Environmental Health and Safety to arrange for pick-up of the waste bottle.
4. Cal Poly Facilities Services-Environmental Health and Safety will dispose of the solid EDW and document disposal per the applicable federal, state, and university regulations.
5. The CDM Smith Team will arrange for the chemical analyses and ultimate offsite disposal of liquid EDW.
6. The CDM Smith will arrange for the soils used in these experiments to be returned to Area IV of SSFL

5.0 Composition and Disposal of Microorganism Culturing Wastes

Bacteria and fungi will be cultured in disposable petri dishes on agar medium containing one of the bioremediation treatability study COIs. Less than 200 disposable petri dishes will be used. Agar medium will contain:

- 100 parts per million (ppm) 30-W motor oil
- 50 ppm naphthalene
- between 0.01 and 100 ppm polychlorinated biphenyls (PCBs)
- between 0.01 and 100 parts per billion (ppb) dioxins

Culturing waste storage and disposal will be as follows:

1. Petri dishes will be collected in a properly labeled Hazardous Waste container..
2. The Cal Poly laboratory manager will contact Cal Poly Facilities Services-Environmental Health and Safety to arrange for pick-up and disposal of this waste stream.
3. Cal Poly Facilities Services-Environmental Health and Safety will dispose of the wastes and document disposal per the applicable federal, state, and university regulations.

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6.0 Containment and Handling of Non-TRFLP or Culturing Wastes

6.1 EDW Containment Devices

The anticipated EDW containment devices for non-TRFLP or culturing wastes are Department of Transportation (DOT)-approved 55-gallon steel containers (drums).

6.2 EDW Container Labeling

An "EDW Container" label shall be applied to each drum using indelible marking. Labeling or marking requirements for EDW are detailed below.

- Include the following information on labels and markings: project name, generation date (beginning and end dates), location of EDW origin, container identification number, sample number (if applicable), contents (i.e., decontamination water), and contact person's name and number.
- Apply each label or marking to the upper one-third of the container at least twice, on opposite sides.
- Position labels or markings on a smooth part of the container. The label must not be affixed across container bungs, seams, ridges, or dents.
- Use weather-resistive material for labels and markings and permanent markers or paint pens. If markings are used, the color must be easily distinguishable from the container color.
- Secure labels in a manner to ensure that they remain affixed to the container.
- Maintain a log of the containers duplicating the label information.

6.3 EDW Container Movement

Pre-determine staging areas for EDW containers. These staging areas will be secure locations and access to these areas will be limited to Cal Poly researchers and graduate students involved in the studies. Determine the methods and personnel required to safely transport EDW containers to the staging areas before activities. Handling and transport equipment will be consistent with the associated weight for both lifting and transporting. A drum dolly, lift gate truck, or fork lift are potential options.

6.4 EDW Container Storage

Stage containerized EDW at a pre-determined secure location at Cal Poly. Store containers such that the labels can be easily read. Provide a secondary/spill container for liquid EDW storage (e.g., steel drums shall not be stored in direct contact with the ground). Storage should not exceed 90 days once a drum is filled.

7.0 Non-TRFLP or Culturing Wastes Disposal Procedures

All EDW generated at Cal Poly for this study will be contained and stored temporarily onsite and disposed offsite. Liquid and solid wastes must be stored separately. Solid waste, including disposable PPE, will be disposed of as solid waste trash in a municipal landfill. Liquid EDW will be retained for disposal in drums, properly labeled, and temporarily stored as described above. Chemical analyses will determine the ultimate disposition of the liquid EDW. The CDM Smith Team will arrange for the chemical analyses and ultimate offsite disposal of liquid EDW.

8.0 Documentation

Document all handling and disposal activities for EDW (per SSFL SOP ST PHY 10, *Cal Poly Laboratory Data Collection, Documents, Content, and Control*). Document any deviations from this SOP and justifications for those deviations.

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